Effects of Aircraft Noise on Student Learning

ACRP Educators' Handbook

Understanding noise, its effects on learning, and what can be done about it.

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Background

This handbook is provided as an accompaniment to the study "*Assessing Aircraft Noise Conditions Affecting Student Learning – Case Studies,*" sponsored by the Airport Cooperative Research Program (ACRP), Project 02-47. This study is available for download from the ACRP website, http://www.trb.org/Publications/PubsACRPWebOnlyDocuments.aspx.

This study focused on schools near the Los Angeles International Airport (LAX), and consisted of classroom observation, noise measurements, and teacher surveys. Observers recorded instances of student distraction, teacher voice raising, and teacher voice masking, and these observations were compared with noise measurements both inside and outside the school building. While no correlation was found between noise and student distraction events, there was clear correlation between aircraft noise and teacher voice raising and voice masking.

Surveys asked teachers to report the effects of aircraft noise on items such as students' attention, concentration, and performance, and their own behavior in raising their voices or stopping explanations. In general, there was significant correlation of these responses with the long-term aircraft noise level at the teachers' locations.

This study adds to a body of literature dating to the 1970's that examinies the relationship between transportation noise and student performance.

Some highlights of this field of study include:

- Cohen (1973) examined reading achivement of students in a high-rise housing complex near an expressway, and found higher achievement among students at higher floors, who had lower noise exposure.
- Bronzaft (1975) found that achievement test scores were lower for students on the noisy side of a school near a railway.

- Green (1982) established an exposure-effect relationship between noise exposure contours around New York City airports and the percent of students reading below grade level.
- The RANCH study (Stansfield, 2005; Clark, 2006) of 2000 students in three European countries showed a consistent decrease in reading comprehension with increasing noise levels. Learning was found to be delayed by 1-2 months for every 5 dB increase in noise level, with reading comprehension falling below average for noise levels above 55 dB (see the next section for an explanation of dB levels).
- FICAN (2007) examined the effect of a sudden reduction of aircraft noise, due to either airport closure or to sound insulation of school buildings. A strong relationship was found to failure rates among high school students, although correlations with other measures and other age groups were less conclusive.

Aircraft noise is thought to be responsible for affecting student learning through a range of mechanisms:

- Speech interference – Elevated noise levels can cause difficulty in students understanding the teacher or each other, causing them to use part of their attention for hearing what is being said, rather than focusing on the content.

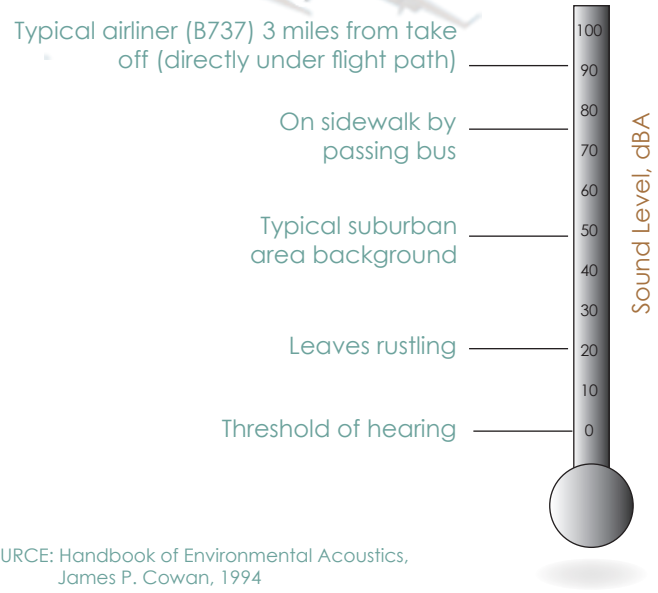
- Interruptions – In situations where noise is characterized by loud, individual events such as aircraft overflights (as opposed to less intense but more continuous sources such as road traffic), it may be necessary for a speaker to stop speaking until the event has passed. This negatively affects the attention of the listeners.

- More subtle effects can include learned helplessness, in which students feel they are not in control of their environment; and annoyance, which can lead to stress responses.

Understanding noise levels and measuring noise in the classroom

To understand how much a classroom might be affected by noise, it helps to have some numbers.

- Sound is measured in decibels (dB), which is a logarithmic scale of sound energy. Some typical sound levels are 25 dB for ambient sound in a rural setting at night; 65 dB for normal speech at a distance of 3 feet; and 95 dB inside a subway train.
- A difference of 3 dB corresponds to a factor of 2 in sound energy. A 10 dB difference corresponds to a factor of 10 in sound energy.
- The recommended background sound level for an unoccupied classroom is 35 dB.
- The recommended speech-to-noise ratio is 15 dB, so, for example, if speech is at 65 dB, the noise in the occupied classroom should not exceed 50 dB.



SOURCE: Handbook of Environmental Acoustics, James P. Cowan, 1994

In order to get a sense of noise levels in the classroom, and to monitor how they change with different noise sources and different noise management strategies, there are simple measurement tools that can be used to observe how a classroom compares to the standards and reference levels mentioned above.

- There are dozens of iPhone and Android apps for doing sound level measurement. These can be useful for ballpark estimates of noise levels, but they are limited by the phone's hardware (microphone and audio processing), which responds primarily to mid-level sounds in the speech part of the audio spectrum. These apps are less effective for measuring very loud or very quiet sounds, or sounds that have strong low-frequency components.

- Dedicated sound level meters will provide more accurate measurements of sound level. A basic meter can be found for $20 that will fit in a pocket. Schools may want to invest in slightly more expensive ($50-$100) meters that include such features as datalogging, a computer interface, and more options for measurement parameters.

Noise management strategies

There is a range of actions that educators can take to address classroom noise. Some of these are already part of the educator's daily toolkit, some can be performed relatively inexpensively and quickly, and some require long-term engagement with school administration and with other institutions in the community.

- Classroom management – It will not come as news to educators that students can be one component of classroom noise, or that noise from any sources can have effects on student attention. Therefore normal classroom management strategies will have a direct effect on noise and its consequences.

  It may be helpful to engage students in a conversation at the beginning of the year about the interruptions due to aircraft noise, and how the class and teacher should respond in order to maintain a learning environment.

- Acoustic classroom treatment – Even if noise comes from external sources such as aircraft overflights, the classroom can exacerbate this noise if sound is allowed to reverberate in the room. A room with acoustically absorbent surfaces will be quieter regardless of where the noise is coming from. Acoustic ceiling tiles, acoustic wall paneling, and carpets can help to dampen noise. As an additional benefit, these treatments will reduce the room's reverberation time, improving speech intelligibility.

- Facility improvements – Educators should ensure that acoustic factors are considered in the course of regular facility maintenance and upgrades.

For example, windows and doors are among the main paths for sound to penetrate the building from outside. If they do not seal well, they can leak sound, just as they would leak hot or cold air. This can often be addressed through routine maintenance. If windows are being replaced, their sound-insulating effectiveness should be one of the criteria considered. Ventilation upgrades should use components that minimize noise from vibration, rattle, and airflow. As mentioned above, acoustically absorbing surfaces should be used to reduce reverberation.

- Airport relations – Educators should engage airports to be sure their concerns are known. Many airports have community advisory boards, and others can be reached via city councils or other institutions. Building these relationships can ensure that airport administrators are aware of how their communities are affected and can help to guide decision making.

- Outdoor activities – London's Heathrow airport has constructed noise shelters at nearby schools to facilitate outdoor learning activities.

Resources

URLs as of July 2017

A collection of resources for classroom noise, including the ANSI standard and related booklets, are available from the Acoustical Society of America at: **http://acousticalsociety.org/about_acoustics/acoustics_of_classrooms**

Smartphone app options are constantly changing; search for **"sound level meter"** on iTunes or Google Play.

Similarly, many choices of hardware sound level meters can be found by an Internet search for **"sound level meter."**

Articles about the Heathrow sound shelters can be found by searching for **"Heathrow domes."** For example, **http://www.huffingtonpost.co.uk/entry/heathrow-airport-third-runway-schools_uk_58107f82e4b0c6d521b53071**

References for the studies cited in the **"Background"** section are listed below. A good overview of these and other studies on the learning effects of aircraft noise is provided in the ACRP document *"Assessing Aircraft Noise Conditions Affecting Student Learning"* (Web-Only Document 16), available at: **http://www.trb.org/main/blurbs/170328.aspx**

Bronzaft, A. L. and McCarthy, D. P. (1975) The effects of elevated train noise on reading ability. *Environment and Behavior,* **7**, 517-527.

Clark, C. and Stansfeld, S. A. (2007) The effect of transportation noise on health and cognitive development: a review of recent evidence. *International Journal of Comparative Psychology,* **20**, 145-158.

Cohen, S., Glass, D. C. and Singer, J. E. (1973) Apartment noise, auditory discrimination, and reading ability in children. *Journal of Experimental Social Psychology*, **9**, 407-422.

FICAN (2007) Findings of the FICAN pilot study on the relationship between aircraft noise reduction and changes in standardised test scores. *Washington, DC: FICAN*.

Green, K. B., Pasternack, B. S. and Shore, R. E. (1982) Effects of aircraft noise on reading ability of school-age children. *Archives of Environmental Health*, **37**, 24-31.

Stansfeld, S. A., Berglund, B., Clark, C., et al (2005) Aircraft and road traffic noise and children's cognition and health: a cross-national study. *The Lancet*, **365**, 1942-1949.