A RESEARCH SUMMARY

IMPACT OF NOISE IN EDUCATION

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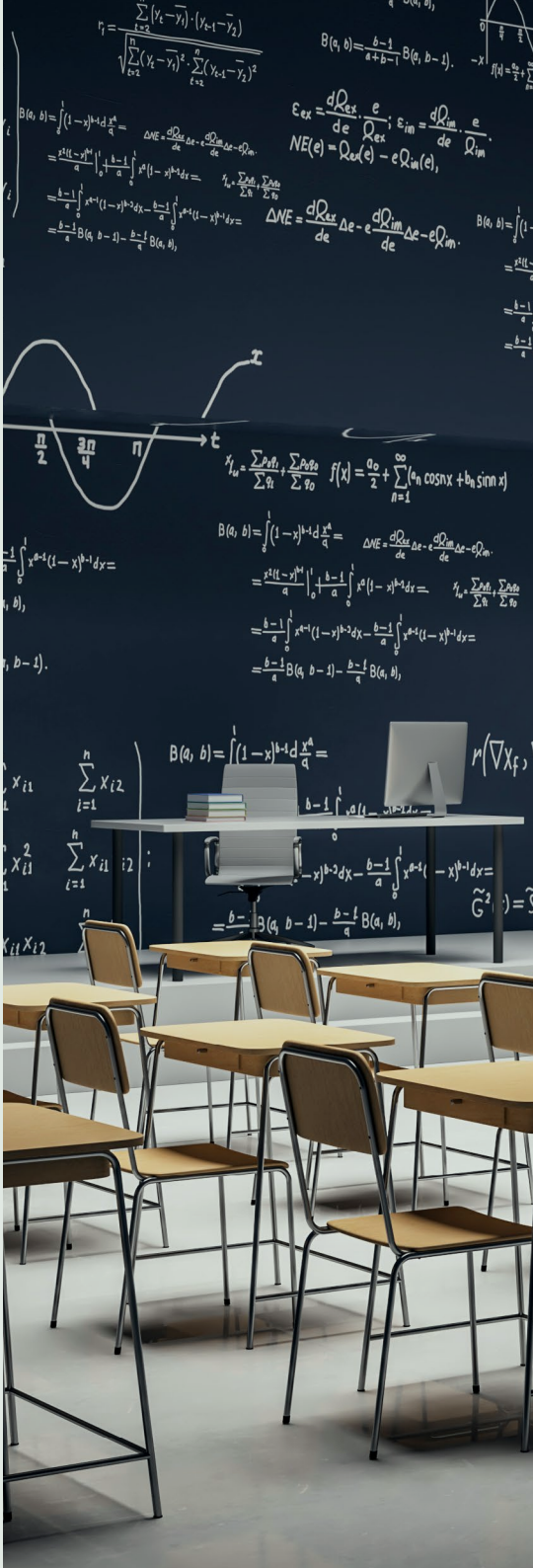
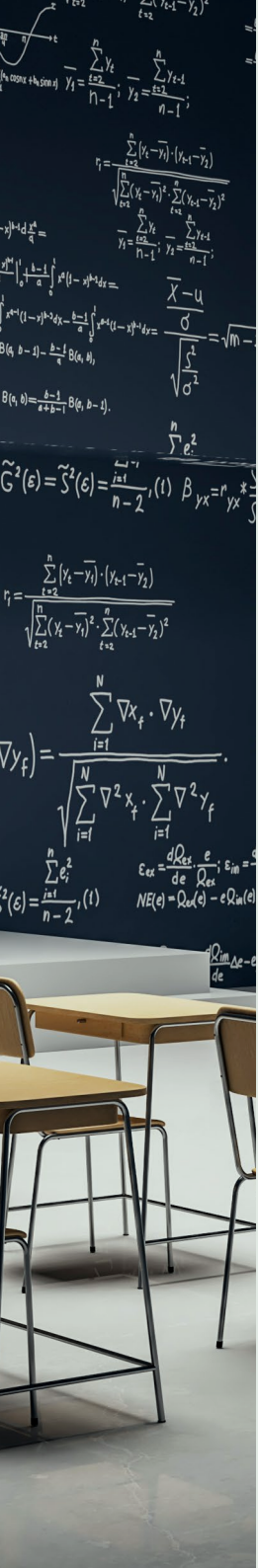




NOISE IMPACT IN EDUCATION

Noise in schools can reach extremely high levels which can negatively influence teachers and students. But by how much and to what extent? And what can we do to improve learning spaces so that they really facilitate the sharing of knowledge instead of hindering it?

In this summary, discover what research definitively reveals:

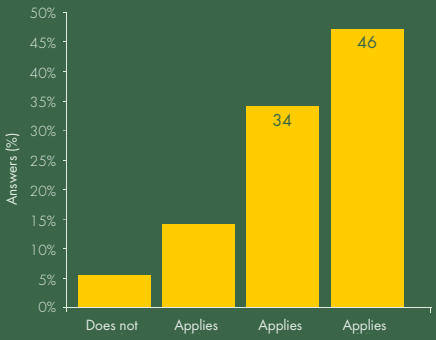
- Recommended healthy noise levels and how they compare with today's average school environment levels
- What it takes to ensure good sound levels in schools
- How noise impacts students' learning capacity and behaviour
- How noise affects teachers and the health risks involved, physically and mentally
- The effect of perceived sound on concentration and annoyance levels in both teachers and students
- Optimising acoustics for inclusive learning
- Noise levels and open plan classrooms
- How noise affects the vulnerable the most

This information is based on a comprehensive literature review process completed over the course of many years by Prof. Bridget Shield, who without their work this summary would not be made possible.

NOISE IMPACT ON TEACHERS AND STUDENTS

We know that good teaching* is the single largest influence on student learning. We want to help teachers to teach even more effectively by providing evidence linking good acoustics with a healthy indoor environment. We have sourced a number of findings indicating the importance of reducing the negative impact of acoustics on teachers:

80% of teachers are stressed by classroom noise[1]

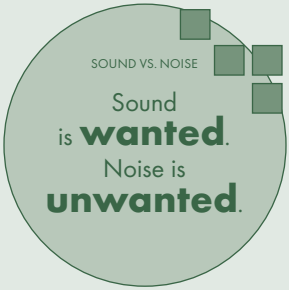


- Over 65% of surveyed teachers have experienced voice problems during their career[2]
- 32% of teachers stated that they have had voice problems, compared with 1% of non-teachers[3]

We must support students in more diversified activities which will help them best adapt in our rapidly changing societies. Students now need 21st Century Skills, including collaboration, communication, creativity and critical thinking skills. These skills demand that students actively engage in their learning process. But the increase in communication brings additional noise to the classroom. This has raised the importance of the acoustic environment a great deal.

Students, with the benefit of good acoustics:

- Increased the number of children reaching government targets in their test scores by up to 13%[4]
- Work more inclusively and better together[5]
- Reduce the sound level in collaborative group work by 13 dB (only 3 dB would be theoretically expected)
- Increased focus and decreased tiredness



SOUND AND NOISE LEVELS

COMMON VS RECOMMENDED

Measuring sound

Noise is measured in a logarithmic unit called a decibel (dB)*. Doubling the sound energy, by adding twice the number of speakers to a room for example, results in an increase in the sound level of 3 dB. Raising the level by 10 dB results in a sound that is twice as loud.

Appropriate noise levels and typical school acoustic guidelines

Research-backed guidelines provide a suitable acoustic range in classrooms for both the average listener and those with additional learning and hearing needs. Outlined below are maximum noise levels which ensure sufficient speech intelligibility and good communication. Levels include unoccupied background noise and the difference required to hear clear speech.

- Maximum ambient noise levels for unoccupied rooms of 30-35 dB[7,8]
- For good speech communication there should be a clear difference in the signal to noise ratio (SNR) of at least 15-20 dB[9]
- Reverberation time (RT) should be approximately 0.5 seconds for learning spaces in which verbal communication is important (a range of 0.3-0.6 s is recommended according to various Nordic countries classroom acoustic standards)

Typical sound levels in decibels	
Four-engine jet aircraft at 100 m	**120** dB
Riveting of steel plate at 10 m	**105** dB
Pneumatic drill at 10 m	**90** dB
Circular wood saw at 10 m	**80** dB
Heavy road traffic at 10 m	**75** dB
Telephone bell at 10 m	**65** dB
Male speech, average, at 10 m	**50** dB
Whisper at 10 m	**25** dB

*Whenever dB is mentioned in this brochure, it refers to dB(A)

AVERAGE CLASSROOM NOISE LEVELS

Noise in schools is dominated by three factors:

- External environmental noise (planes, trains and automobiles)
- Student generated noise in their learning activities
- Mechanical sound sources from within the room (ventilation, projectors, computers)

A recent study[10] documented noise levels in hundreds of school classrooms while students were having lessons. They discovered that students learning in noisier classrooms had poorer learning outcomes and behaviour.

LESSON NOISE LEVELS AFFECTS STUDENTS' ACADEMIC PERFORMANCE:

Results of the research revealed that children learning in classrooms in which there were high noise levels performed worse on reading tasks than children learning in classrooms with lower noise levels. This suggests that acoustic treatments that reduce noise will benefit children's reading in many schools.

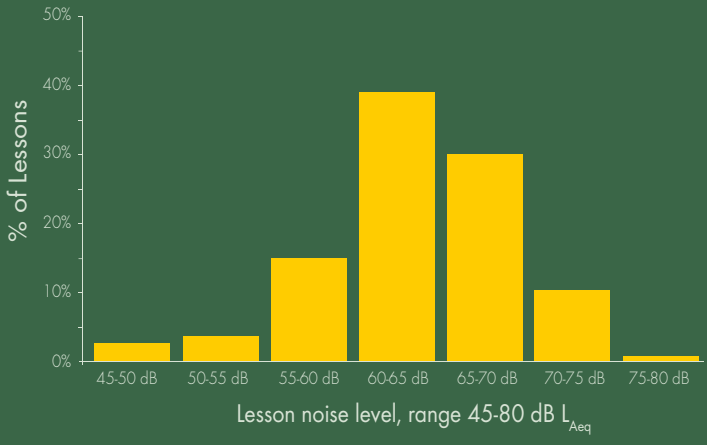
LEGISLATION LEADS TO REAL IMPROVEMENTS:

When legislation for school acoustics was introduced in England and Wales in 2003, it doubled the number of schools with optimal sound environments for their learners. This shows that schools worldwide stand to benefit greatly from acoustic standardisation and legislation.

ACOUSTIC CONDITIONS AFFECT STUDENT COGNITION AND BEHAVIOUR:

The time taken for students to recover from auditory disruptions (eg. students talking or shouting) shows that having high noise levels can negatively impact students' ability to concentrate[4,10]. These levels have also been linked to lower scores on tests of reading, spelling and related tasks[4]. These impacts are even greater for children with special education needs[11].

Noise survey of 274 lessons[10]



ACHIEVING GOOD ACOUSTICS

FOR OPTIMAL VERBAL COMMUNICATION

There are two clearly identified aspects that influence a school's acoustic environment: noise and reverberation time*. In classrooms, noise may have many sources: air and vehicle traffic coming from outside, building services (heating, lighting, ventilation systems), technology (projectors, computers) as well as noise from the students themselves.

The quality and intelligibility of speech depends both on the level of noise and on the amount of reflected sound. Sound reflects off, and is amplified by, surfaces in the room including: walls, ceilings, floors, tables and whiteboards. Too much reflected sound from hard and flat reflecting surfaces degrades the quality of speech and increases the noise level.

Achieving the best acoustics for verbal communication is essential. To support all facets of communication, from speaking to, hearing and listening, it's necessary to look at building and acoustic design from various perspectives.

Key factors for sufficient sound reduction from internal sources include:

- Lowering internal noise levels (eg. from installations and activities)
- Shortening reverberation times to minimise unwanted sound reflections
- Optimising speech intelligibility as a result of reducing reverb time and increasing the signal to noise ratio (SNR)

Designing for external noise reduction

Sound insulation from external sources, minimal service noise and intrusion from other spaces.

*The reverberation time (RT) in a room quantifies sound reflections from surfaces. RT measures the time taken for a sound to decay by 60 dB, and is directly influenced by the amount of sound-absorbent materials in a room. Optimal RT for speech is shorter, approximately 0.5 seconds, whereas longer times of up to 2 seconds are acceptable in rooms where speech has less primacy, such as music auditoriums.

EFFECTS ON LEARNER PERFORMANCE

This study[4] compared different levels of background noise to understand their degrees of impact on learning. When comparing the effect of "quiet" versus "average" levels of background noise on common educational tasks, researchers found large differences in performance.

Typical classroom babble at an average of 65 dB has a significant impact on arithmetic, verbal and cognitive tasks.

They found that lower noise levels allow students to process information more quickly, giving their responses a higher level of accuracy. This study also demonstrates that adolescents' reading comprehension is vulnerable to unfavourable levels of classroom noise. Children that were not functioning optimally to start with, due to having a cold or fatigue for example, were also more severely affected by the babble noise.

Effects of classroom babble on performance of primary school children

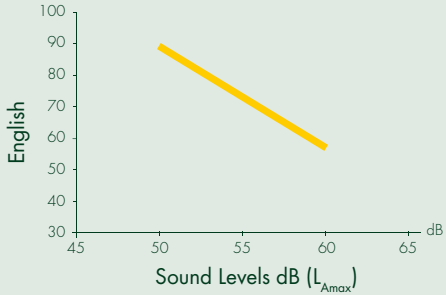
NOISE INTERFERES WITH THE PROCESSING OF LANGUAGE

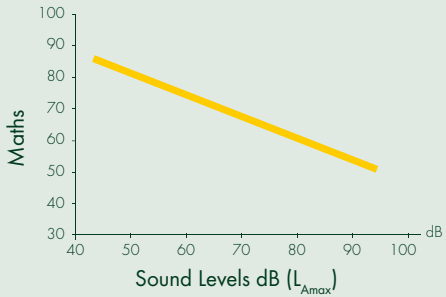
This study[4] demonstrates how the impact of noise is detrimental to the academic attainment of students'.

Comparing school standardised assessment test scores of young students with internal noise levels found significant negative relationships between the ambient background sound levels in classrooms and test scores for several subjects.

Interestingly, the test which showed the strongest association with noise was the language test. These findings suggest that background noise in the classroom interferes with general processing of language.

Increasing the noise levels clearly lowers the scores in two fundamental subjects, with a more dramatic impact in English.





GOOD ACOUSTICS IMPROVE SPEECH INTELLIGIBILITY BY MORE THAN 35%

Researchers made groundbreaking findings[11]. They discovered that most noise in school classrooms was not caused by the assumed noise from planes, trains and automobiles, but by the students themselves during learning activities.

They also found that by introducing a high performing "Class A" absorption ceiling:

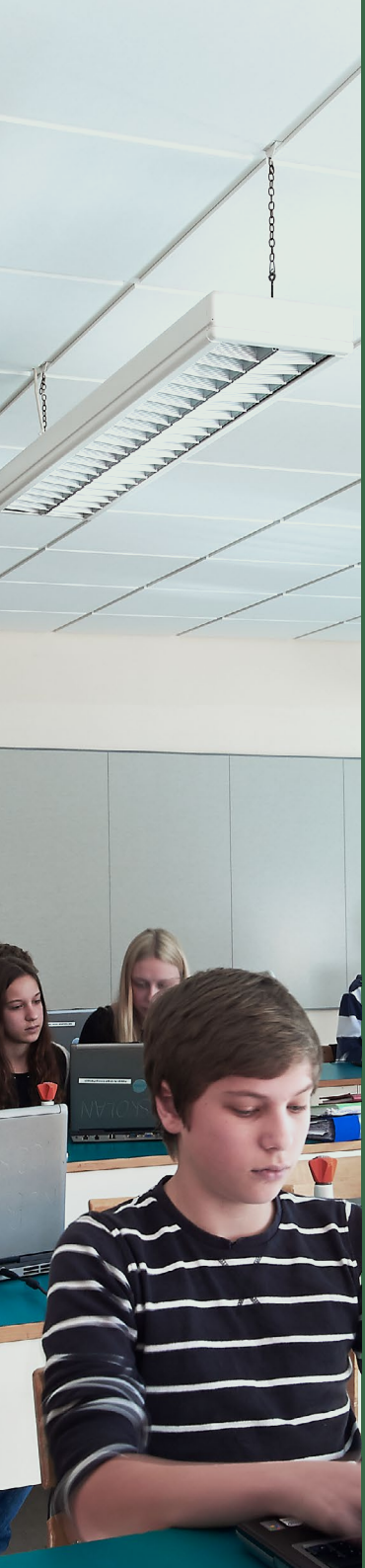
- Students' word recognition improved by 35%
- Perceived sound level was reduced by half

Reducing noise levels has a physical and behavioural impact

The theoretical effect of installing a Class A sound absorbing ceiling was predicted to be a 3 dB sound level reduction for an unoccupied classroom. However, the real change was in the behaviour of the people in the classroom. Since everyone could be heard and understood without raised voices, students and teachers immediately spoke more quietly, in fact 7 dB more quietly, with a reduction of 10 dB overall.

Better for group learning

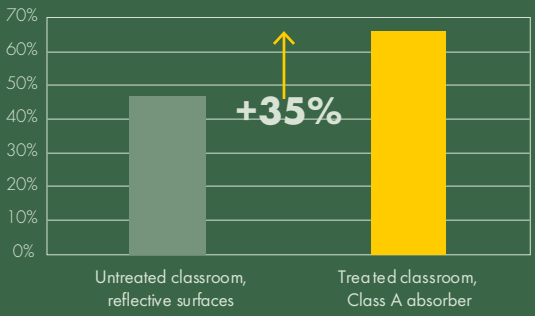
The acoustic treatment reduced the background noise levels and shortened the reverberation time, resulting in better student performance in word intelligibility tests. The improvement was particularly positive when many students were talking simultaneously in the classrooms.



Staff working in the treated classrooms say there's an enormous difference. Not only do they not have to shout to be heard, but there's generally a calmer, quieter and more relaxed atmosphere in the classroom. We're all delighted.

HEAD TEACHER MISS CATHERINE DOUGLAS OF BALGREEN PRIMARY SCHOOL

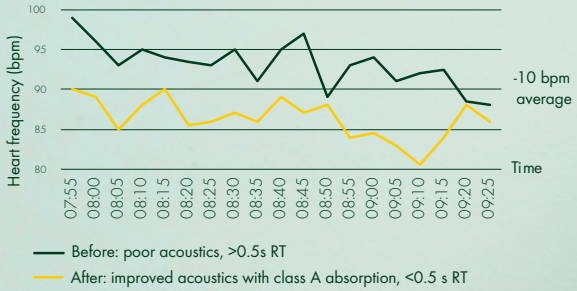
Percentage of correctly identified words



GOOD ACOUSTICS LOWER HEART RATES

When it was realised that 80% of teachers were stressed by noise, researchers decided to find out if stress levels could be reduced by improving the sound environment. They also sought to discover how classroom noise actually affects teachers and students during activities[1].

Comparing teachers' heart rates in poor vs good sound envrionments (with Class A acoustic absorbers) showed that heart rates calmed down by up to 10 beats per minute (bpm) when acoustics were improved



How it's possible

If a classroom has poor acoustics, sound is amplified as it bounces off the reflective ceiling and walls. This creates background noise which distorts speech. Sound levels then escalate because instructors and learners have to raise their voices to be heard. This is called the Lombard effect[15]. As a result, the environment will often feel progressively more stressful as the class (or day) continues. (Please also see the study described on page 20 about how the Lombard effect influences students' behaviour.)

Reducing noise and reverberation time reduces stress

Acoustically treated classrooms transform the space into a more relaxed environment where everyone feels calmer, resulting in lower teacher heart rates. Teachers experience considerably less stress in classrooms when reverberation time is less than 0.5 seconds.

VOICE PROBLEMS

VOICE PROBLEMS SHOW THAT TEACHERS' HEALTH IS AT RISK

Sadly, it has been consistently shown that teachers develop more voice problems than other occupations.

Threats to teacher vocal health

Based on numerous studies on teacher vocal health, teachers are at least twice as likely to have voice-related problems versus other occupations.

- Over 65% of teachers surveyed experienced voice problems during their career[2]
- Teachers represented 16.4% of those diagnosed with voice disorders while being only 2% of the working population tested[12]
- 32% of teachers stated that they've had voice problems, compared with 1% of non-teachers[3]

Teachers miss **more than twice** as many days of work as those in other occupations.

CONSEQUENCES OF VOICE PROBLEMS

ON TEACHERS' WORKING LIFE

This large-scale study[13] compared voice-related work problems and work absence between 2,400 workers from different professions over the course of a year. The findings show that teachers are more likely than any other worker group to restrict work activities and miss more days of work due to voice-related problems.

Comparison of work-related problems in previous year among teachers and non-teachers

	Prevalence (%)	
	Teachers	Non-teachers
Reduced activities on at least one day	43	16
Missed at least one day of work	18,3	7,2
Missed more than 5 days of work	3	1,3
Voice not functioning as usual for more than 5 days	35	22
May need to change job because of voice	2.0	0.78

NOISE IMPACT ON STUDENT

CONCENTRATION AND BEHAVIOUR

Improving acoustic conditions has implications on the number of dysfunctional activities

This study[14] investigated whether classroom noise level changes have a direct relation to student behaviour. During five morning lessons, 'dysfunctional' activities increased in classrooms with worse acoustics (RT 0.6 to 0.75 s), while in the rooms with 'better' acoustics (RT 0.4 to 0.5 s), dysfunctional activities remained approximately the same throughout the morning.

Lombard effect[15]

As the day progresses, classrooms with poor acoustics result in more dysfunctional and disruptive behaviour following the progressive rise in noise levels[15].

Acoustic improvement changes students' behaviour

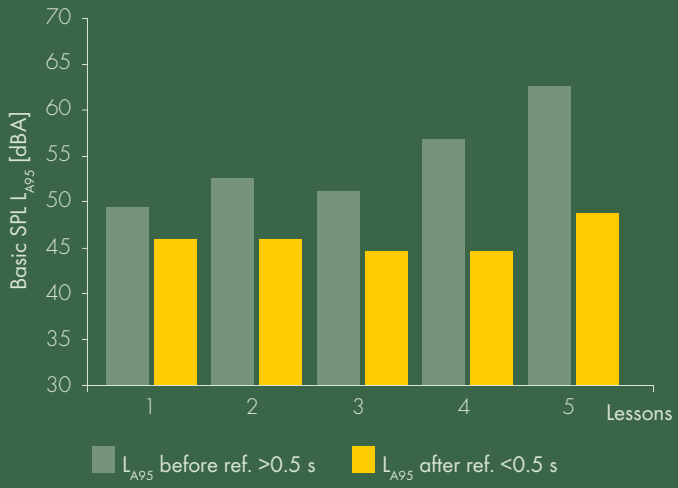
A sound-absorbing ceiling reduces the overall sound level in the classroom and reduces the activity noise which altered the behaviour of students in a very positive way.

Easier listening encourages better behaviour

This study also monitored "dysfunctional activities" during lessons[14]. This included interjections or disruptions as a result of activities not relating to the lesson. As the sound levels were reduced, so were the dysfunctional activities, which resulted in increased concentration during the lesson.

When noise levels are controlled, the levels of student concentration remained the same across the lessons. This consistency with improved acoustics negates a large source of fatigue and stress in the classroom.

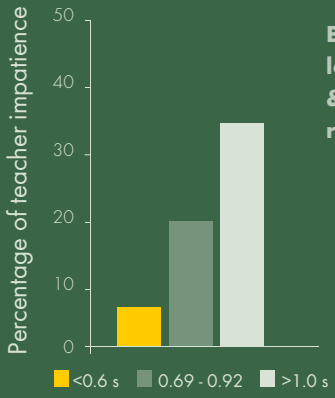
Increase of activity sound levels (L_{A95}) before and after refurbishment



POOR ACOUSTICS CAUSE ANNOYANCE

While investigating the effects of classroom acoustics on children and teachers, researchers found a direct correlation between reverberation time and annoyance for both groups[16].

Children from the more reverberant classrooms gave lower ratings of motivation and quality of interaction with peers and teachers. (Typical classroom acoustic recommendations are for reverberation times to be around 0.5 s.)



Excessive reverb lowers motivation & reduces student rapport with teachers

Parents were also asked this question: “My child suffers from the noise produced by his or her classmates in school.” Results showed that the least amount of annoyance occurred for children being educated in rooms that had been treated to reduce reverberation time.

Classroom acoustics (RT)	% annoyance
<0.6 s	44%
0.7-0.9 s	51%
>1.0 s	61%

Lowering RT reduces children’s level of annoyance

NOISE SOURCES,

ACOUSTIC CONDITIONS AND SPEECH CLARITY

How noise and reverberation affects the intelligibility of speech in a classroom has been investigated extensively. Both objective as well as subjective measures point to the fact that impacts on speech reception can be huge.

One way of measuring speech intelligibility is the Speech Transmission Index (STI). The higher the STI, the better the quality of speech communication for all students.

Research[17] shows that STI values are related to the quality of speech intelligibility* for all students. However, impact is greater for younger children. Certain types of noise also affect STI more, with babble noise generated by other students having a greater impact on ineligibility than non-human sounds like ventilation, for example.

This means that it is essential to make acoustic improvements that reduce the impact of speech-based noise in the classroom environment, such as lowering reverberation time.

STI descriptor	STI
Bad – poor	0,30
Poor – fair	0,45
Fair – good	0,60
Good – excellent	0,75

The Speech Transmission Index (STI) demonstrates the degree of speech intelligibility from low to high using values between 0 and 1

* Speech intelligibility is also influenced by the signal to noise (S/N) ratio, which is the difference between the signal (in this case, speech) and background noise in a room.

SPEECH MUST BE HEARD CLEARLY

ABOVE BACKGROUND NOISE

To hear and understand what is said in classrooms requires good speech intelligibility at an audible level. The speech needs to be heard above the ambient background noise. This is called the signal-to-noise ratio (SNR).

The younger the listener, the greater the SNR needs to be in order to hear spoken language clearly above the noise. One important study[9] indicated that while 15 dB could be considered a satisfactory SNR for the older children (age 11), the youngest children (age 6) required an SNR of up to 20 dB to provide adequate speech intelligibility.

Younger learners need bigger signal-to-noise ratios (SNRs) to hear speech

Age	SNR required for 75% to achieve 90% intelligibility score
6 year olds	+20 dB
8 year olds	+18 dB
11 year olds	+15 dB

In a later study[18], researchers investigated speech perception in the presence of noise in order to find maximum acceptable levels of ambient classroom noise. They found that younger children needed a higher SNR than older children in order to achieve the same speech intelligibility score of 95% when there was a background noise level of 35 dB.

OPTIMISING ACOUSTICS

FOR INCLUSION OF ALL STUDENTS

Researchers tested how successive changes in acoustic treatment affected noise levels in the classroom once they were upgraded according to recommendations for children with hearing loss[5]. For every upgrade improving acoustics for children with special hearing needs, they found that both students and teachers became quieter and calmer.

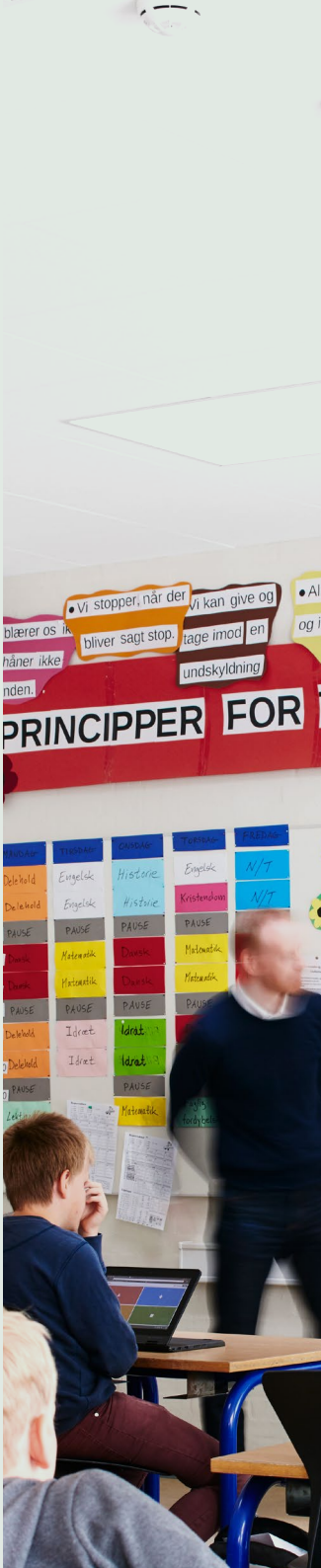
Results showed that following these recommendations produced a sound environment that was both inclusive and beneficial for everyone else in the room. Learners generated less noise and instructors did not have to speak as loudly or strain their voices.

Acoustic improvement resulted in:

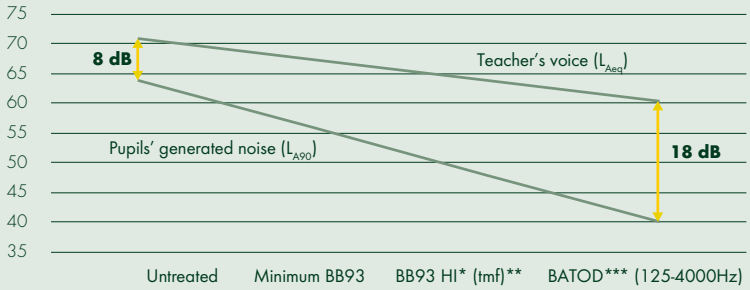
- More classroom discussions and group work
- More effective teaching and fewer repetitions
- Reduced teacher stress levels

Increasing sound absorption lowered occupied sound levels

A sound-absorbing ceiling reduces the overall sound level. Adding additional low-frequency absorbers reduces background noise and improves speech clarity.



Classroom noise and signal to noise ratios showed remarkable improvements as the acoustics were adjusted to meet inclusive standards



These improvements in RT should theoretically have produced a reduction of only 3 dB in sound levels in the classroom. But the data showed that the teacher was able to speak over 10 dB more quietly after refurbishment because the underlying noise generated by the students was so much lower.

Additionally, the signal-to-noise ratio (SNR) between the teacher's voice and the pupils' generated noise was also able to increase beneficially by up to 10 dB (from 8-18 dB). This means that following acoustic recommendations allowed the critical SNR of 15-20 dB to be reached, making listening conditions ideal for those with hearing loss as well as younger children[17].

As the acoustic treatment improves, the SNR increases and the pupils were found to require less effort to understand the teacher, and the vocal effort and stress of the teacher were also reduced.

The classroom with the highest-performing acoustic treatment including additional low-frequency absorption was consistently rated as providing the best conditions for both speaking and listening.

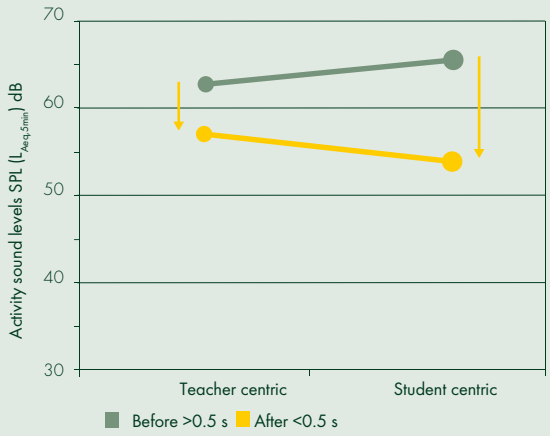
IMPROVED ACOUSTICS SUPPORT

COLLABORATIVE GROUP WORK

A study in Germany compared classrooms with long and short reverberation times (RT). They found a significant reduction in noise levels between them when the classrooms were occupied and the students were engaged in different learning activities. In the treated room, the sound levels were reduced dramatically with shorter RT, enabling:

- collaborative group work, because learning activities can be carried out with much lower sound levels
- the teacher to speak at a lower level, reducing voice strain
- workload stress reduction due to the noise reduction

Activity sound levels before (green) and after (yellow) refurbisment: the treated rooms reduced noise levels by 6 dB for traditional teaching and 13 dB for group work



A room that's acoustically treated is especially beneficial for group work because a number of people can speak at the same time, but more quietly, and without the need to compete in the volume of their speech.

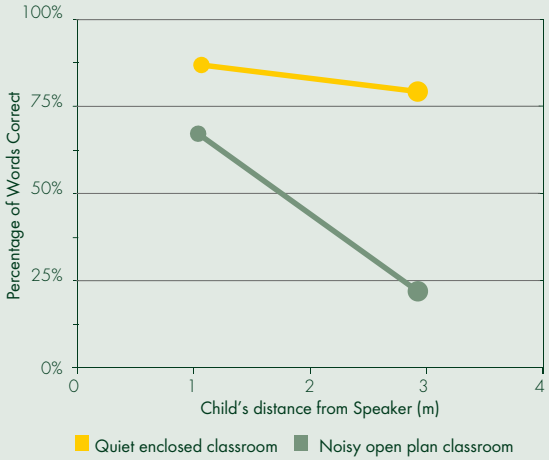
You buy a 3 dB sound reduction and you get 10 for free!

DR G. TIESLER

OPEN-PLAN CLASSROOMS

Researchers compared noise levels in four types of kintergardens with different spacial designs: one enclosed and three open-plan designs of different sizes[19].

Intrusive noise was measured for quiet activities (whole class teaching) and noisy ones (group work) in all the classrooms. Intrusive noise levels increased with the size of classroom and number of class groups, both for adjacent quiet activities and for noisy activities.



In open plan classrooms the further away the listeners are from the speaker the greater number of incorrect answers given.

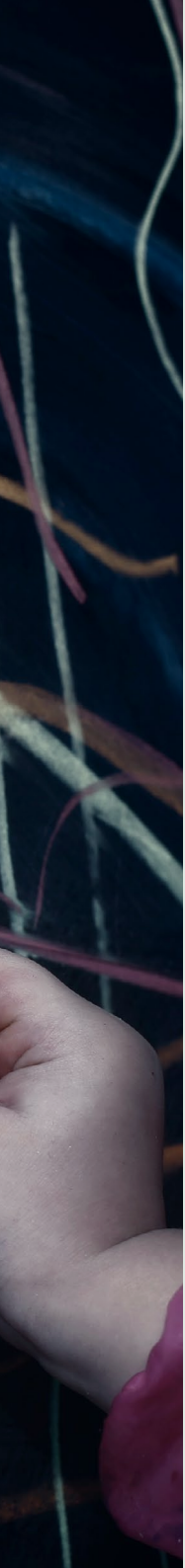
Even when surrounding open classes were engaged in quiet activities, children at the back of the large open classrooms were disadvantaged due to higher noise levels. The above diagram shows that in a quiet, enclosed classroom, with an absence of outside noise distraction and disturbance, it's possible to hear to the back of the class.

In open-plan spaces, another factor that contributes to reducing speech intelligibility is that the listener is often further away from the speaker. In order to maintain speech intelligibility in open-plan designs, one technique could be to cluster listeners closer to the speaker in order to reduce the distraction caused by intrusive sounds from adjacent spaces and learner groups.

RESPONSES TO NOISE IN OPEN PLAN CLASSROOMS

Looking at extensive studies[20] researchers have determined that sound levels during activities are not conclusively higher between open-plan and enclosed classrooms.

Despite the common perception that noise levels are higher in open plan spaces, noise levels appear to be quite similar to closed classrooms.

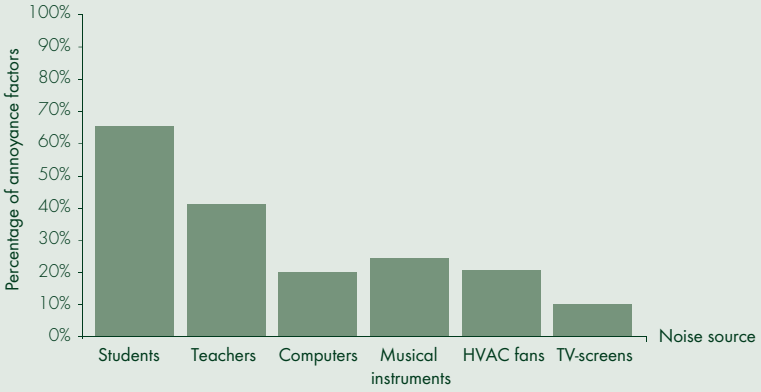


In some, levels were higher in an open-plan, however, in some cases they were lower. This is possibly due to low reverb times as a result of increased absorption and/or appropriate classroom management.

Noise, however, from other students outside the classroom is frequently cited as a source of annoyance and disturbance for open-plan classrooms in both open primary and secondary schools. Children being taught in open plan classrooms are particularly susceptible to hearing irrelevant speech and, indeed, in surveys of open plan schools, speech from adjacent teaching areas has been cited as the most common form of disturbance[21].

When asked to rate sounds that were the most annoying in open plan classrooms, 65% were fellow students from other classes, followed by teachers from other classrooms.

Sounds which annoy students in open-plan primary school classes



THE VULNERABLE SUFFER THE MOST

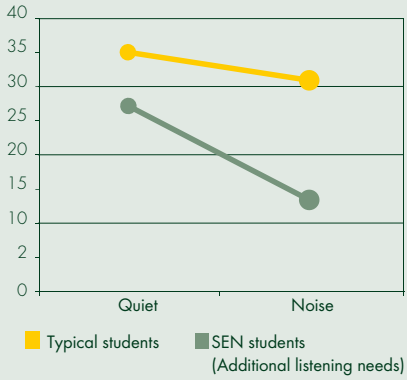
In any classroom there are a number of learners with special education needs (SEN) that influence their ability to hear speech and cope with noise. This not only includes hearing loss but also those with attention problems and those learning in a second language. Interestingly, it applies to anyone who is not in optimal condition, for example having under-slept or being under the weather.

Hearing impairment increases the risk of stress and fatigue and requires more effortful listening, which may jeopardise a child's ability to learn in a noisy environment and thus compromise their performance.

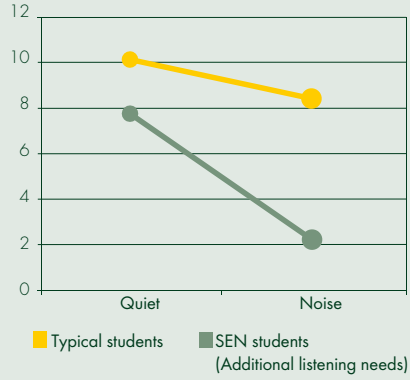
In order to learn more, researchers compared performance between regular and SEN primary school children on a series of tasks including literacy and speed of processing. The tasks were undertaken in quiet conditions as well as when babble noise of 65 dB was introduced – a background noise level common to most classrooms evaluated.

The results showed children with SEN were most negatively affected, especially in the babble condition. They also revealed that test scores from learners with additional needs plummeted when the environment became noisy, whereas typically-developing learners were much less impacted.

Maths scores in noisy vs. quiet conditions



English scores in noisy vs. quiet conditions



HEARING-IMPAIRMENT STANDARDS

SET THE CRITERIA FOR INCLUSION

Students with additional listening needs/SEN are vulnerable to challenging sound environments but also attend mainstream schools which are often not optimised for them. Inclusion policies and recommendations are therefore designed to support their learning in these environments.

Students that fall into the additional listening needs group commonly include those with hearing loss and cognitive problems, but also those that are not being educated in their first language. Children that fall on the autistic spectrum are also vulnerable, showing increased instances of disturbing behaviour as the environmental noise increases[22].

A comprehensive list of groups with additional listening needs includes:

- Permanent sensorineural/conductive hearing impairment
- Fluctuating conductive hearing impairment (caused by colds, ear infections, etc.)
- Speech, language and communication difficulties
- Attention Deficit Hyperactivity Disorder (ADHD)
- Auditory Processing Disorder (APD)
- Being on the autism spectrum (ASD)
- Additional-language learners

To enable an inclusive learning environment, students should have increased speech intelligibility. Standards which recognise the importance of controlling reverberation at low frequencies for sensitive listeners deliver just that.

All recommendations for students with additional listening needs also benefit to typically-developing students as well as teachers because they create a better sound environment for everyone in the room as well.

In addition to the SEN groups mentioned, it is important to remember that the classroom also consists of younger children with developing auditory systems. They need a higher signal to noise ratio (SNR) in order to hear the teacher's voice above the background noise[9,18]. And that is exactly what following these recommendations has been shown to provide[5].

Below, a standards summary from the UK (BB93[7] & BATOD[8]) for noise and reverberation in SEN classrooms

Acoustic criteria – additional listening needs	BB93 (2015)* BATOD**	
	New build	Refurbishment
Indoor ambient noise level*	≤ 30 dBA	≤ 35 dBA
Reverberation time*	≤ 0.4s, average 125 Hz to 4000 Hz octave bands	
Signal to noise ratio**	>20 dB, 125 Hz to 750 Hz	
	>15 dB, 750 Hz to 4000 Hz	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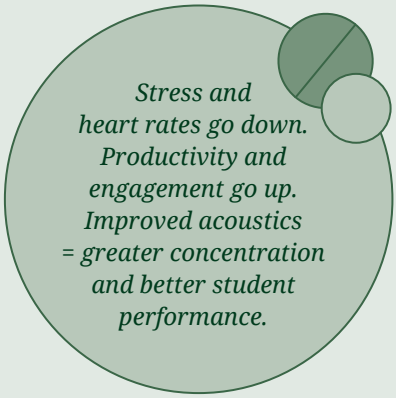
CONCLUSION

In order to provide suitable working and learning environments that support the development of education – including critical 21st century skills – a good sound environment is a fundamental necessity.

We believe this research summary provides much-needed knowledge and awareness of the positive impact of improving acoustic environments. We believe acoustics is a key component for teachers and students, in their overall health and wellbeing during teaching and learning activities. Good acoustics can support critical aspects of a positive culture in education. The result is enhanced participation and engagement for all.

When schools are designed with good acoustics, everyone can communicate more easily. The practice of sharing knowledge and ideas becomes a more productive experience. Imagine the exponential impact if teachers were able to remain focused on teaching instead of controlling noise and disruptions, while students could spend longer periods engaged in deeper states of learning.



Teacher testimonials from studies[5,14] with improved acoustics reveal:

- Significant improvement in working conditions for both staff and students, describing the improvements to be a quieter and calmer sound environment
- Better classroom behaviour and comprehension
- Lower stress levels for teachers, especially those with less experience
- Hearing-impaired students participate in classes on more equal terms

For a deeper look into the impact of acoustics in educational environments, please see Ecophon's blog Acoustic Bulletin (www.acousticbulletin.com) where we dive more deeply into studies, standards and issues relevant to the world of education.

REFERENCES NUMBERED THROUGHOUT. BY AUTHOR(S), TITLE, DATE:

1. Schönwälder, H.-G., Berndt, J., Ströver, F., Tiesler, G. Professional stress and strain in teachers (in German), Schriftenreihe der BAuA, Fb 989, NW-Verlag, Bremerhaven, Germany. 2003.
2. Comins, D. Survey of UK voice clinics 2001/2. Voice Care Network UK. 2002.
3. Smith, E., Lemke, J., Taylor, M., Kirchner, H. L., & Hoffman, H. Frequency of voice problems among teachers and other occupations. Journal of voice, 12(4), 480-488. 1998.
4. Shield, B M., and J E. Dockrell. "The effects of environmental and classroom noise on the academic attainments of primary school children." The Journal of the Acoustical Society of America 123(1). 2008.
5. Canning & James. The Essex study –Optimising classroom acoustics for all. 2012.
6. McKenzie & Airey. Classroom acoustics, a research project – Summary report. 1999.
7. Department for Education. Building Bulletin 93 - Acoustic design of schools: performance standards. Education Funding Agency, London, 2015
8. British Association of Teachers of the Deaf (2001) Classroom acoustics - recommended standards. BATOD Magazine, January 2001.
9. Bradley, J. S., & Sato, H. The intelligibility of speech in elementary school classrooms. The Journal of the Acoustical Society of America, 123(4), 2078-2086. 2008.
10. Shield, B., Conetta, R., Dockrell, J., Connolly, D., Cox, T., & Mydlarz, C. A survey of acoustic conditions and noise levels in secondary school classrooms in England. The Journal of the Acoustical Society of America, 137(1), 177-188. 2015.
11. Shield, B., Connolly, D., Dockrell, J., Cox, T., Mydlarz, C., & Conetta, R. The impact of classroom noise on reading comprehension of secondary school pupils. In Proceedings of the Institute of Acoustics, 40, 236-244. 2018.
12. Smith, E., Gray, S. D., Dove, H., Kirchner, L., & Heras, H. Frequency and effects of teachers' voice problems. Journal of voice, 11(1), 81-87. 1997.
13. Roy, N., Merrill, RM., Thibeault, S. Parsa, R. A., Gray, S. D., & Smith, E. M. Voice disorders in teachers and the general population: effects on work performance, attendance, and future career choices. Journal of Speech, Lang and Hearing Research, 47. 2004.
14. Tiesler, G. Communication Behaviour and Workload of Students and Teachers in Highly Absorbent Classrooms. In Proceedings of Euronoise. 2018.
15. Brumm, H., & Zollinger, S. A. The evolution of the Lombard effect: 100 years of psychoacoustic research. Behaviour, 148(11-13), 1173-1198. 2011.
16. Klatte, M., Hellbrück, J., Seidel, J., & Leistner, P. Effects of Classroom Acoustics on Performance and Well-Being in Elementary School Children. 2009.
17. Astolfi, A., Bottalico, P., & Barbato, G. Subjective and objective speech intelligibility investigations in primary school classrooms. The Journal of the Acoustical Society of America, 131(1), 247-257. 2012.
18. Yang, W., & Bradley, J. S. Effects of room acoustics on the intelligibility of speech in classrooms for young children. The Journal of the Acoustical Society of America, 125(2), 922-933. 2009.
19. Mealings, K. T., Demuth, K., Buchholz, J. M., & Dillon, H. The effect of different open plan and enclosed classroom acoustic conditions on speech perception in Kindergarten children.2015.
20. Shield, B., Greenland, E., & Dockrell, J. Noise in open plan classrooms in primary schools: A review. Noise and Health, 12(49), 225. 2010
21. Greenland, E. E. (2009). Acoustics of open plan classrooms in primary schools (Doctoral dissertation, London South Bank University). 2009.
22. Kanakri, S. M., Shepley, M., Tassinary, L. G., Varni, J. W., & Fawaz, H. M. Observational study of acoustics design and repetitive behaviors on children with autism. 2017.

Ecophon is the leading supplier of indoor acoustic solutions that improve working performance and quality of life. We believe in the difference sound can make to our everyday lives, and are passionate advocates for the importance of room acoustics to people's wellbeing – whatever the space, activity or need.

Having a sound effect on people is the principle that guides all we do. We're proud of the Swedish heritage and human approach that promise is founded on. Our uncompromising commitment to transparent sustainable practice. And, as members of the Saint-Gobain Group, to be doing our part in making the world a better home.

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