

The Insidious Effects of Classroom Acoustics on Student Performance

A Dramatization of the Problem

Picture yourself walking into a school to visit your friend Nancy who has just landed a job as a first grade teacher at Moon Elementary. Nancy is a skilled and enthusiastic young teacher who was recruited into a low performing school by a new principal who is charged with implementing new initiatives to improve student achievement.

As you walk into the school a couple of days before the new school year begins you notice that the hallways are dimly lit with barely enough light to read the room numbers without effort. You find room 314 and open the door. You are struck with the scene of Nancy hanging an ABC border above the white board in the front of the room. What amazes you is that there is only one 40 Watt light bulb in the ceiling, right above the center of the front row of desks and no windows. Nancy greets you and chatters rather nervously about how nice her new principal is and the new approaches to improve academic performance. Nancy draws you to the back of the classroom to show you the new phonics curriculum. Although you can see the book, because of the low light it takes an extra moment to get oriented and you have to put a bit more effort into comprehending the detail in the illustrations and print other than the larger titles. You wonder how the students that will be seated in the back of the classroom will attend to the text if they have to work to see in the shadows.

As she continues to describe the new teaching initiatives and the special teaching coaches that have been hired you begin to think that it is no wonder that children struggle academically if they have to struggle in class every day to clearly see what is going on. And it is no surprise that any child with attention or learning difficulties would be even more challenged in an environment where they have to put extra effort into every aspect of understanding of what they strain to see. Even socially it now seems understandable that Moon Elementary has a reputation for the numbers of children who act out in the classroom.

Finally you find yourself asking Nancy if anyone at Moon school had mentioned the low light and how it affects student performance. She said that she had been concerned too, but the principal assured her that members of the Superintendent's office had come to Moon Elementary and felt that there was no problem – that they could see the white board just fine during a short visit to the school. As you leave Nancy's classroom and exit the school you shake your head and question the level of success that will occur due to all of the effort to improve student achievement if such a simple, but important, foundation to learning is not addressed.

The Invisible Foundation to Learning

There is no question that if a school had poorly lit classrooms that there would be an outcry and a demand to improve lighting so that children could clearly see to learn. Substandard classroom acoustics are not as obvious as lighting although the effects of poor classroom listening may be even more significant than those caused by poor lighting. It is an assumption in education that children who are paying attention in the classroom will be able to easily hear what the teacher says, and learn. For too many children, this assumption is untrue. A recent Canadian study indicated that **one in six words** is not understood by the average first grade student due to excessive noise and poor classroom acoustics. Much of classroom instruction is primarily verbal, especially in the lower grades when foundation skills are learned. A bedrock educational skill is reading – an ability that relies on being able to perceive small auditory differences between letter sounds and words, which is challenging to learn in a sea of noise.

Realities of Classroom Acoustics

1. Appropriate acoustic treatment in classrooms costs 1%-5% of the typical construction budget of a new school – less than the landscaping. In general, providing appropriate acoustics is not a considered a priority, resulting in 'value engineered' (lowest bidder) ventilation systems and cheap acoustic ceiling tile.
2. National standards for classroom acoustics were established by the American National Standards Institute (ANSI) in 2002. Research indicates that only 10%-30% of classrooms meet these standards. Indeed, now that there is a building boom for schools there is a reemergence of 'open plan' schools that are substantially less expensive to build, but acoustic nightmares that are almost impossible to retrofit.
3. In a national survey of schools almost 30% of classrooms were judged to be too noisy by educators. Noise is typically due to the whoosh and hum of heating and air conditioning ventilation (HVAC) systems that cycle on and off throughout the teaching day, masking one lesson after another and taxing the listening energy of students. The other culprit is excessive reverberation – or reflected sound off hard surfaces that smears perception of words.

Who is most challenged? The students who are most challenged by excessive noise and reverberation are under the age of 13, especially those in kindergarten and first grade. The auditory physiology that allows humans to effectively listen in relatively noisy conditions does not mature until secondary school, with some aspects not maturing until the end of high school. Our youngest students are also those with immature language learning and lack the words needed to expertly fill in the blanks when a new word or word ending is missed.

Why is there a challenge? Even with good behavioral control of classrooms to minimize student-generated noise a teacher can do little or nothing to reduce background ventilation noise or reverberation. These two work together as a one-two punch that can affect speech perception, attention, behavior, and overall classroom performance.

Risks to teachers? Because adults are so much better at listening effectively in noise and reverberation, the impact of the acoustic environment is almost always underestimated by teachers, administrators and parents. Veteran teachers too often believe that when they talk loudly the noise will not be a problem to students who are paying attention. This belief has resulted in teachers being at 20 times the risk of average workers for permanently damaging their voices. The average teacher takes at least 1 sick day per year related to vocal strain. The funds a school district must invest just to pay for these substitute teachers would have been better spent on acoustic treatment when the school was built.

Ineffective solutions: Even with this personal investment of the teacher's health, the desired result is still not good enough. When you raise your voice the louder and longer vowel sounds are heard more clearly, but the consonants stay weak (you cannot yell an /s/ or /f/ sound). We need to hear the higher pitch, quieter consonant sounds clearly to tell the difference between words such as cat, cap, cast, calf. Unfortunately it is the quieter high pitch speech sounds, typically consonants that are most easily covered up by noise and smeared by reverberation. It is not surprising that the students in the back half of the classroom usually do not seem to be as engaged or actively learning as those next to the teacher. As the teacher moves, she brings the loudness of her voice with her. This can help students throughout the classroom hear – but only the students closest to her as she moves.

Value of preferential seating? How close is close enough to really hear all of the speech sounds? It depends on the background noise. Typically the noise present is equal or just a little quieter than the loudness of the teacher's voice. To perceive 100% of speech sounds children need to hear the teacher's voice spoken 15 dB louder than the background noise. Like the example of Nancy's classroom, it is only the children that are closest to the teacher who will really be able to perceive the most information with the least amount of effort. With this in mind, preferential seating is not enough to overcome poor acoustics especially for a child has any degree of hearing loss.

ESOL listeners? The speech perception accuracy and listening effort of children who are not native English speakers is similar to children who have 25-40dB hearing losses, creating an additional challenge to this increasing population of American students.

Effects on learning! RATE: In noisy and/or reverberant classrooms the least effects are seen when students are involved in practicing skills they already know, like math drill problems. The greatest effect is seen when students are introduced to new words or concepts. There is little wonder why some schools with similar demographics are able to move through a curriculum more quickly while others that have poor acoustics learn at a slower pace with need for more class time to learn the same concepts. **PERSISTENCE:** Even more insidious is the finding that children who are educated in noisy classrooms tend to give up faster when faced with learning challenges. This lack of perseverance is a serious limitation to a healthy learning attitude and our current need to be accountable for every child's school achievement.

ACHIEVEMENT: It is not surprising that students in schools next to noisy freeways or under airport approach flight paths can have a 1 year drop in grade equivalent achievement scores for every 10 dB increase in traffic noise in the classroom.

NO HABITUATION: Finally, there exists the belief that when a teacher speaks quietly or when noise is present that the children will learn to tune in and focus more intently. This may be true in the short term, but children in noisy educational settings learn to tune out – not tune in. The energy needed to listen more carefully leaves less mental capacity to process the information that is being presented and saps the length of time that students can truly employ. Noisy classrooms tend to be wigglier and require more repetition than in classrooms where children do not have to put as much effort forth to listen.

So What Can be Done?

1. Place this article in the school staff room to raise awareness of this issue.
2. If you think your school has more than 35dBA of noise when classrooms are unoccupied then you may be in one of the 70%-90% of schools who do not meet ANSI standards for classroom acoustics. The school district educational audiologist can estimate the noise and reverberation present (or an acoustical engineer if you have no audiologist).
3. Bring the idea of acoustics and the effect on student achievement to the attention of your administration. If one of the cornerstone foundations of learning is not sufficient it is no wonder that some schools are struggling more than others, even with the same student demographics present.
4. There is no 'simple fix' that will erase the effects of poor classroom acoustics. The key is the background noise present in the classrooms, which must first be reduced. To help achieve lower levels it is necessary to install good acoustic ceiling tile, consider switching to quieter HVAC systems and, in noisy communities, installing better windows.
5. In classrooms with adequate reverberation times (0.6 seconds or less) and background noise that is within 10 dB of the 35 dB noise standard putting a microphone on the teacher and loudspeakers in the classroom is a simple idea that can have a big impact on student attention and learning. Think of how the overhead projector helps all students see clearly what is written. Sound field amplification improves the loudness of the teacher's voice over the background noise. This allows the teacher to speak at a conversational level and lets the students throughout the classroom to hear without undue effort – leaving them mentally more ready and able to learn. Beware - if there is greater than 0.6 seconds of reverberation time then sound field amplification can actually be more detrimental to listening and the smearing of speech sounds. A sound field amplification system is not sufficient for students with hearing loss who will require personal FM amplification to be able to auditorily access verbal instruction. Some savvy school districts are investing in appropriate acoustic ceiling tile, quieter HVAC systems and installing sound field amplification in every classroom – a true listening advantage and edge to learning! Teachers who have frequent vocal issues and absences could request this technology as an ADA accommodation that will allow them to continue their teaching career.
6. Sound field amplification technology will NOT improve all classroom listening environments (and is rarely appropriate for children with hearing loss)! If reverberation in the classroom exceeds 0.6 seconds and background noise exceeds 45 dB or if the school is an open plan environment then much more investment will be required to improve the acoustics of the learning environment. Installing good acoustic ceiling tile is a first step and these actions can do much to improve the acoustics in many schools. Some heating and air conditioning ventilation systems are too noisy and should never have been purchased for a school environment. In this case it may be possible to put baffles or other retrofits into the system that will dampen noise. In the case of open plan schools the ventilation systems have been designed for large area circulation of air and simply putting walls up to control noise is not an option without replacing the whole ventilation system. An acoustical and/or mechanical engineer can provide guidance.
7. Finally, educators and school administrators need to be aware of the effects of classroom acoustics on the successes and the struggles of students. Achievement is multifaceted and listening to learn is a cornerstone foundation to learning.

For more information refer to the following:

For a detailed review of classroom acoustics literature and complete references refer to:

<https://successforkidswithhearingloss.com/wp-content/uploads/2011/08/Kids-in-Noisy-Classrooms-What-does-the-research-really-say.pdf>

For valuable resources go to: <https://successforkidswithhearingloss.com/resources-for-professionals/impact-on-listening-and-learning>

For a summary of the Classroom Acoustics Standard (ANSI S12.60) go to:

<https://successforkidswithhearingloss.com/resources-for-professionals/impact-on-listening-and-learning/classroom-acoustics-standard>

www.acoustics.com/ansi_education.asp <http://www.mcsquared.com/rt60aa.htm>

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