

High Performance Schools Equals High Performing Students

By Steven J. Gertel, Paul J. McCarty EdD, and Lorenz Schoff PE

Classroom acoustical design and the use of sound enhancement systems are discussed in light of their impact on student academic achievement as well as teacher health and welfare. The results of a multi-year study conducted by Orange County Public Schools in Orlando, Florida, which introduced sound enhancement systems into many of their elementary and secondary schools are reviewed.

Across the United States, architects, planners and facility professionals are championing a wide range of facility "solutions" to address the education crisis in our schools. This includes adopting sustainable building practices; utilizing life-cycle cost analysis; increasing indoor air quality; introducing technology into the classroom; developing community centered schools; and designing small schools or schools-within-schools. The crisis for facility professionals centers on school buildings. Unfortunately, school administrators see the crisis differently. They are looking for ways to improve the quality of the educational environment. This means improving student performance and addressing a huge assortment of inter-dependent problems and diffuse objectives that seem insurmountable such as school board accountability, reduced construction funds, standards and testing, teacher attendance, low salaries, student attendance, rising dropout rates, low parental involvement, reading scores, school day length, local control, school choice, community involvement, whole-school curriculum, computers, student mobility, benchmarking, student culture, security, project based learning, and differentiated learning modes.

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Facility professionals speak a jargon that most school administrators do not understand, and provide solutions that seem to have little relevance to the day-to-day challenges administrators face. At the same time, school administrators have tried every new pedagogical technique to address this crisis, but with minimal success. They have experimented with redesigning curriculum, eliminating non-academic electives, increasing professional development, hiring more teachers, lengthening the school day, lengthening the school year, improving food services, etc. Research, however, shows that changes in the physical environment have the most immediate impact on learning. Improvements in classroom acoustics, in particular, may have the greatest impact on student learning (Rittner-Heir 2001).

The optimum acoustical learning environment

The optimum learning environment is critically based on auditory-verbal responses. Children spend 45 percent of their day engaged in listening activities (Berg 1987). Teachers spend most of their time talking, while students ask questions, and listen to both the teacher and other students (Palmer 1997). But if students cannot hear, no learning can take place. Research has shown that the ability of students to learn, and thus their overall academic performance, is negatively impacted when the teacher's communications are muddled or blocked by reverberation or background noise. The standard response is for teachers to raise their voice over the din and project it to the farthest ends of the classroom. After six hours of straining, the teacher invariably leaves school physically exhausted. Over time, this physical effort takes its toll on teacher effectiveness and longevity. Student's inability to listen or hear the teacher inevitably leads to their "tuning out" the lecture. Above all, the student's desire and ability to learn diminishes due to the student's incapacity to distinguish directions or failure or lack of desire to stay on task (Palmer 1997). Poor listening also requires increased effort to learn, and thus reduces the energy available to perform other higher-order cognitive functions.

Research has shown that a typical classroom provides an inadequate environment when auditory learning is the primary tool of instruction (Palmer 1997). As many as one-third of all students miss 33 percent of verbal communication in a typical classroom. Transient external noise generated by children at play, aircraft, vehicular traffic, and ground-mounted air conditioning equipment all penetrate the building envelope and disrupt learning. Internal noise generated by desks and chairs moving, student groups, children moving about, equipment in the classroom, air conditioning and ventilation systems, electrical humming, adjacent classroom activity, and students changing classes in the corridor also penetrate the classroom. The problem of noise has become so important that the American National Standards Institute (ANSI) has developed background 35 decibel, A-weighted thresholds for the maximum sound level within a classroom. Yet, interestingly, ANSI neglects to address not only noise generated in the classroom, but also the signal-to-noise ratio. In order to be properly heard, the teacher's voice must be at least 15 decibels higher than the ambient noise. The higher the ambient noise

level, the greater the strain on the teacher and the higher the probability that words are neither heard nor understood. This coupled with the acoustical characteristics of a classroom (which is often assumed to be adequate), designing a proper acoustical environment becomes a formidable task.

Why is this so important?

Information in speech is contained in consonant sounds. The human voice is not designed to project consonant sounds, and because of their frequency range, they are difficult to transmit over the ambient sound level. For those students who come from homes where a second language is spoken, their inability to hear the language clearly in the classroom demands that they either assume what is being said or learn an incorrect pronunciation. The inability to hear clearly also leads to inattentiveness and behavioral problems (Flexer 2002a and 200b). Often, these "attitudinal" problems are a reflection of the student's frustration with not being able to hear, rather than their desire to be disruptive. Students are not small adults; their auditory brains are not fully developed until the age of fifteen (Crandell 1998). In a noisy environment, an adult can fill in the missing words, finish a train of thought, or understand the underlying meaning of the teacher due to past knowledge or experience. A student does not have the experience or familiarity to make these associations.

Sound enhancement systems and classroom acoustical design

A recent Cornell University study (Evans 2001) suggests that classroom noise not only interferes with the student's ability to hear the teacher, but it may contribute to a state of *learned helplessness*. In this state, the student feels powerless over the classroom environment and gives up trying to learn, thus putting them at even greater risk for failure. Common everyday noise also functions as a stress factor, raising systolic blood pressure, increasing heart rate, and raising cortisol levels and psychological stress.

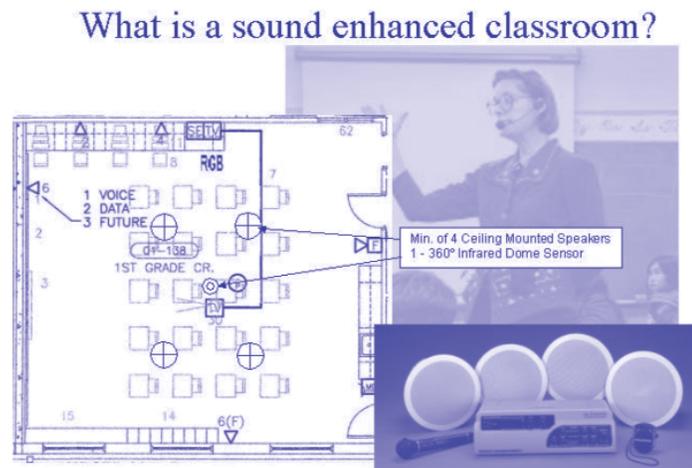
Room reverberation time can be corrected by increasing the amount of absorptive surface materials, decreasing the volume of the room or increasing the directionality of the sound. To reduce ambient noise, the school can re-route air conditioning systems, place furniture on felt pads, install insulating windows, gasket door openings, change teaching habits, or require students to be completely silent.

Sound enhancement systems utilize a wireless microphone (infrared), a receiver, and at least four strategically located ceiling mounted speakers in the classroom to distribute the teacher's voice down onto the students. These systems are not sound amplification systems, which only increase loudness and are normally uni-directional. When these sound enhancement systems are used, every student feels as if they are in the front row of the classroom; each can hear the words of the teacher distinctly and at the same time. The student is immediately involved in the learning process. While not actually making the classroom louder, the teacher controls, stabilizes, and equalizes the acoustical environment, thus ensuring instructions are heard

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by all students. Hearing the higher frequency sounds that carry the sounds and nuances of word boundaries and consonants enables the student to hear the difference between "night rate" and "nitrate". Speaking in a normal, comforting voice reaches out to students, giving them the sense of a one-on-one relationship, regardless of their distance from the teacher. Sound enhancement systems also have a positive effect on teacher performance, attitude, and health. The teacher is able to talk over any interfering background noise. As subtle as the system is, students fail to notice the ease of listening until the system is turned off.

Research has shown a direct correlation between the implementation of classroom sound enhancement systems and improved academic performance (10-15 percent gains per year) regardless of class size, individual learning needs, socio-economic status, and English Language Learner proficiency. The effect sound enhancement had on teacher absenteeism was equally impressive. One study showed a 36 percent drop in teacher absenteeism in sound enhanced classrooms.



Why Teachers Have Voice Problems

Most cases of voice problems among teachers are ultimately attributed to poor acoustical conditions in schools. These voice problems are often a major cause of physical "burn-out", vocal fatigue, and other related illnesses that have a profound effect on teacher retention. When sound enhancement systems are installed in classrooms, teacher absenteeism declines. This saves school districts thousands of dollars in substitute teacher costs and vital student-learning hours. The fact is, teachers are not educated or trained in healthy vocal use and they often lack the knowledge of sound enhancement systems. It is estimated that 75 percent of voice difficulties experienced by teachers can be prevented or self-managed. The National Institute of Health has taken initial steps to address this critical but often-overlooked health issue by underwriting a no-cost website devoted entirely to educating teachers about their speaking voices. The site, called the Voice Academy (www.voiceacademy.org), includes information about the use of enhancement systems.

Schools can be a vocal health hazard zone for teachers. A recent study found that teachers are thirty-two times more likely to be plagued with voice problems compared with other professionals (Sapir 1993). Teachers frequently report symptoms of hoarseness, pain, or fatigue when speaking, as well as temporary loss of voice. These problems also restrict the student's ability to learn and impair the teacher's quality of life and attitude toward teaching. They may progress to the point where skilled teachers leave the profession permanently (Smith 1998).

In 1996, Dubuque Community School District in Iowa reported teachers in classrooms without sound enhancement averaged fifty-two sick days per year due to voice, jaw, or throat problems (0.93 sick days per teacher). However, teachers in sound enhanced classrooms took only nineteen sick days per year (0.34 sick days per teacher) for the same problems. The Iowa teachers reported sound enhanced "equipment was user friendly and made it easier for them to project their voice throughout the classrooms" (Laurie Allen, Keystone Area Education Agency, Dubuque, Iowa, 1996). In addition to fewer teacher sick days, the increased use of sound enhancement equipment in schools resulted in substantial annual savings for the school districts in substitute teacher pay. "The Dubuque Community Schools employ approximately 650 full time teachers. Their substitute teacher pay is approximately \$62 per day. Every 12-14 sick days saved by the District would cover the cost of another classroom system" ((Laurie Allen, Keystone Area Education Agency, Dubuque, Iowa, 1996).

Students in a sound enhanced classroom learn at a faster rate, at a higher level of complexity, and with less repetition of information. The use of this technology not only fulfills the technological criteria of the No Child Left Behind Act, but also creates an optimum acoustical environment essential for effective learning and teaching. Sound enhancement systems compensate for inadequately designed room acoustics and are ideal for retrofitting existing classrooms to immediately improve learning.

Orange County Public Schools

Some of the nation's largest school districts are beginning to believe that a key to urban school reform is improving the acoustics of the instructional environment. In these days of continuous high stakes testing and federally mandated accountability standards, urban school districts are concerned with the following two major challenges:

- How to improve test scores for No Child Left Behind (NCLB) targeted students
- How to increase teacher retention

Orange County Public School District (OCPS) in Orlando, Florida, may have found the answer to both challenges. OCPS recognized that the classroom listening environment is key to improving urban school test scores and introduced sound enhancement systems into many of their elementary and secondary schools. The results of a multi-year study showed

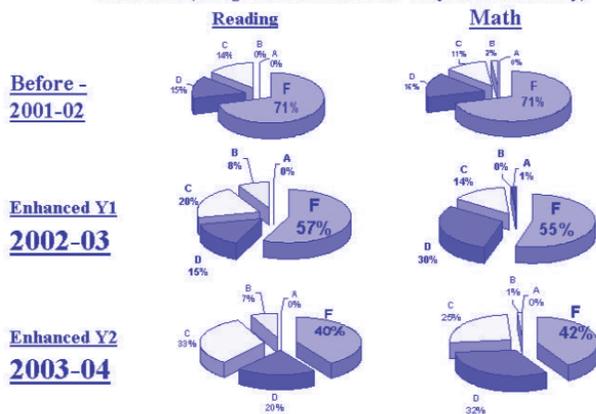
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that students in sound enhanced classrooms scored 10 percent higher on average on the Florida Comprehensive Achievement Test (FCAT) than students in classrooms without sound enhancement. Teacher absenteeism was also 25 percent less in the sound enhanced classrooms. An example of this dramatic student improvement is Ivey Lane Elementary in Orlando, Florida. Principal Darryl Weathers was given the assignment of turning around a failing, Title One school with a high minority population. Motivated by OCPS's infectious can-do attitude and district support, Weathers installed sound enhancement equipment (about \$1600 per classroom) that contributed to the school moving from a "F" to an "A" school. The teachers also experienced less vocal fatigue.

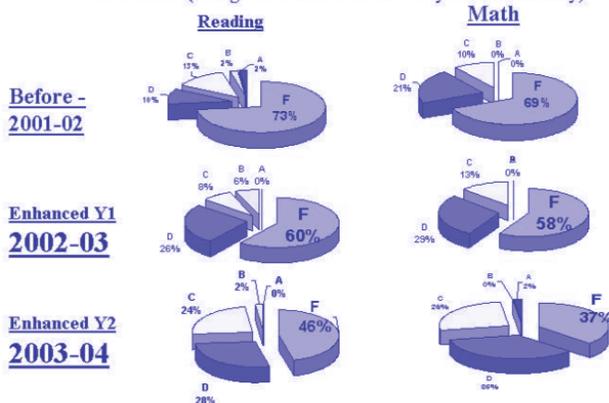
Today, OCPS requires sound enhancement systems in every new and renovated school. This requirement is an important part of the Orange County Public Schools \$2.7 billion school construction program that will extend through 2015. The Orange County Public Schools school design standard has become a model for other school districts throughout the nation. For example, Ohio has adopted Orange County's sound enhancement concepts for their construction standards for new and renovated schools (*Ohio School Design Manual 2003*).

Denver Public Schools is another national leader in implementing sound enhanced classrooms. It recently passed a bond to purchase sound enhancement equipment for its schools after conducting extensive pilot studies that showed improved student achievement and on task behavior. The infrared microphones and ceiling speakers helped teachers speak in normal, comforting voices that reached out to each student. Schools that used audio enhancement have also seen an equally impressive improvement in teacher instructional performance and attitude, as well as less voice fatigue. "It's sort of a no brainer," said Allen Balczarek, Program Manager for the Denver Public Schools. "The 'back row' is eliminated, so to speak. And, the teacher can save her voice, and consequently her career!"

Effect Sound Enhancement has in Reversing 3rd Grade Previously Failing Test Scores (Orange Co. Public Schools - Ivey Lane Elementary)



Effect Sound Enhancement has in Reversing 4th Grade Previously Failing Test Scores (Orange Co. Public Schools - Ivey Lane Elementary)



What is the effect sound enhancement has on urban secondary students?

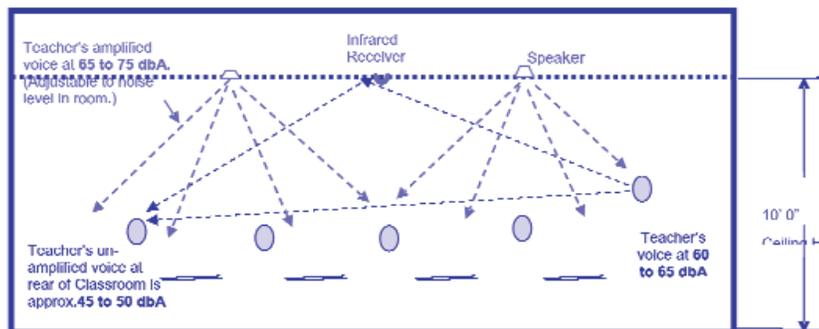
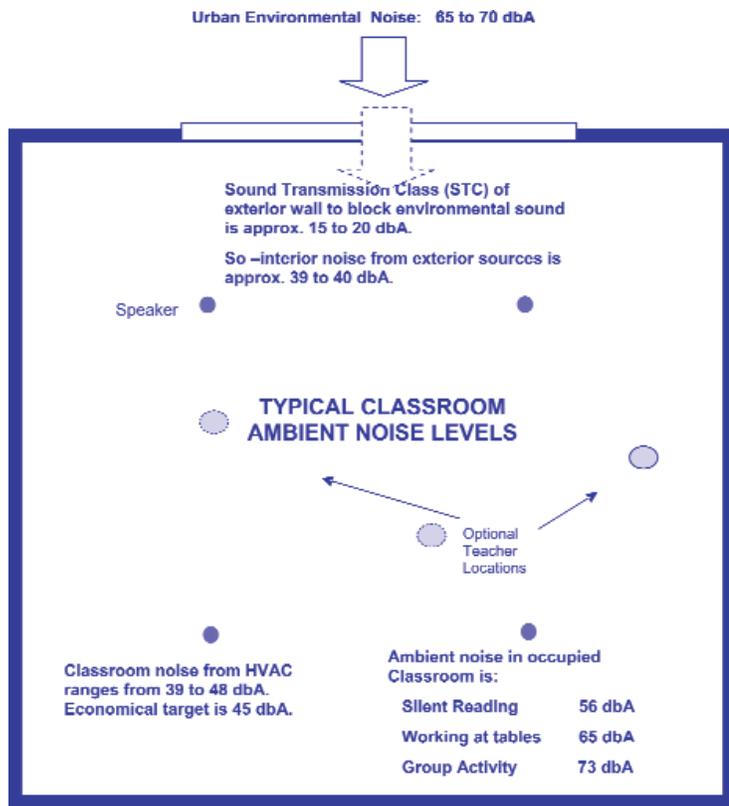
Florida's State Demonstration Middle School, Ocoee Middle School, in the Orange County Public Schools, has also experienced dramatic increases in FCAT test scores due to sound enhanced classrooms. Ocoee's Principal, Dr. Kate Clark, and her teachers ranked sound enhancement as the number one technology at the school. Their ceiling mounted LCD classroom projector sound systems were run through the voice enhanced ceiling speakers. According to Clark, "Every child can see and every child can hear, clearly." Dr. Clark noted that with the introduction of sound enhancement systems, "the decrease in discipline problems alone was obvious." There was a 40 percent decline in discipline incidents from previous years. Dr. Clark attributed the disciplinary decrease to the increased ability of students to focus and remain on task. She added, "The impact for students and teachers has been unbelievable."

Conclusion

Studies in urban schools have shown the importance of sound enhancement in the classroom. It makes sense. If students are to understand the message, they need to hear it clearly. It is a key factor for educational facility planners and architects to consider when designing high performance schools that maximize student performance. Politicians, researchers, and educators have spent much effort, time, and money in their quest for strategies, textbooks, and methodologies to enhance learning performance. Adding sound enhancement to the initial school design will achieve dramatic results. It would be challenging to find another idea for improving student performance that has a better cost to benefit ratio. The results for all students are too dramatic and the benefits are too promising to ignore.

Analysis of student FCAT scores in other district secondary schools in the Orange County Public Schools showed similar student achievement and improvement. Student comprehension increased and discipline problems in the classroom decreased while teachers experienced less fatigue at the end of the school day.

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EFFECT OF SOUND ENHANCEMENT IN CLASSROOM

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