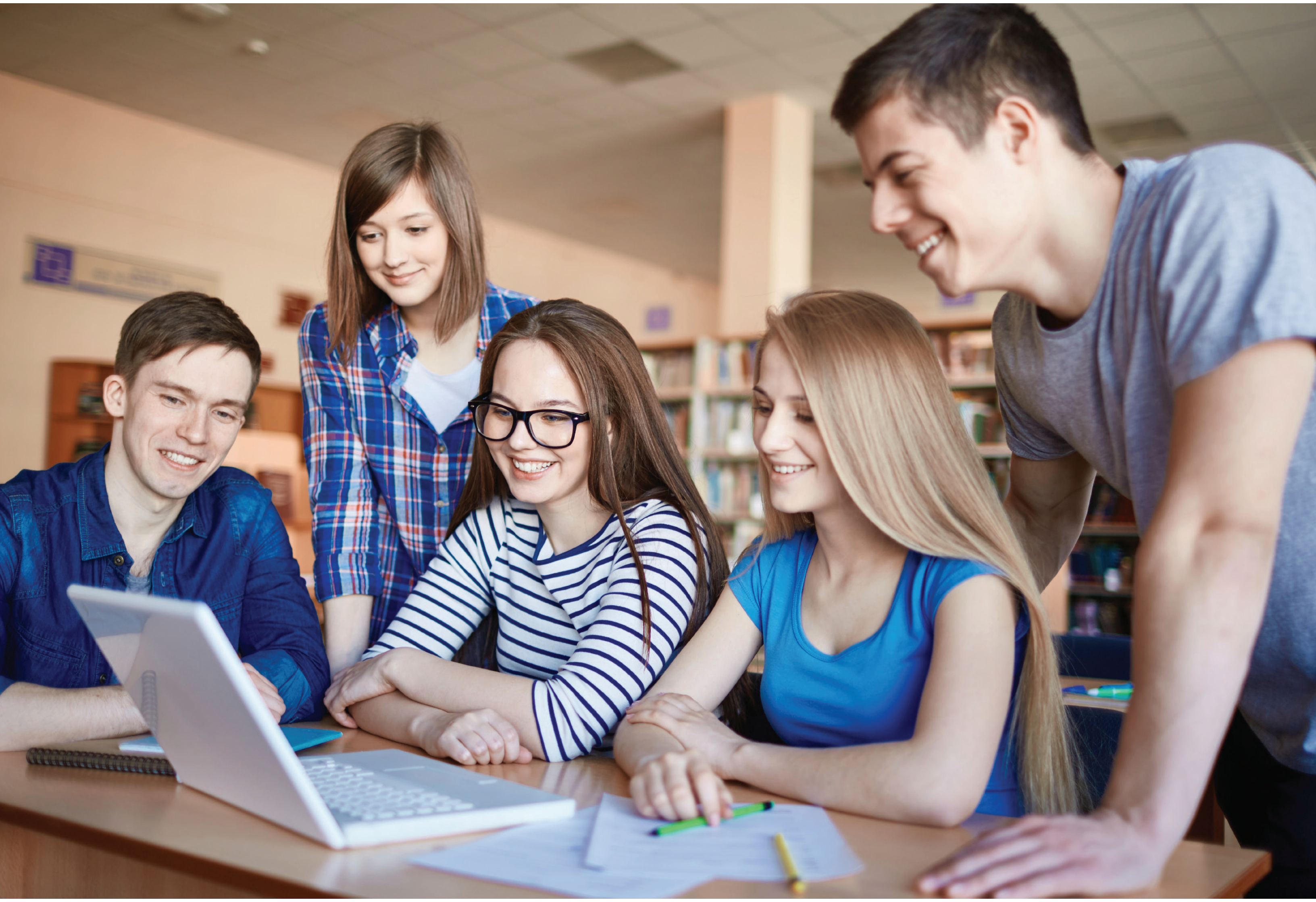
Acoustics and the Impact on Educational Facilities



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Achieving High-Quality Acoustics in Schools

The move to a collaborative teaching environment is bringing with it a change in classroom acoustics. Here's what you need to know about sound, noise and creating acoustically beneficial environments in schools.

Sound is a rapid variation of pressure at a certain point in space: whether a room reverberates primarily depends on its size and the capacity its exposed surface to absorb sounds. Hearing is sometimes strained by reverberation, causing a certain degree of stress through time. Stress is closely related to the mental fatigue caused by spending an extended period of time in rooms with inefficient acoustics.

In "Classroom Acoustics II: Acoustical Barriers to Learning," by Peggy B. Nelson, Ph.D., Sigfrid D. Soli, Ph.D., and Anne Seltz, M.A., a publication of the Technical Committee on Speech Communication of the Acoustical Society of America (http://acousticalsociety.org/), a number of reasons are outlined why schools need quiet learning spaces for students and teachers. They include the following:

- Because students under age 15 are still developing mature language and need appropriate listening environments to understand the spoken message.
- Because many learning spaces serve students with disabilities: learning disabilities, language learning problems, behavior problems, reduced cognitive skills, hearing loss, auditory processing disorders and chronic illnesses. These students have a special need for classrooms that allow clear listening and communication.
- Because teachers should be able to use a natural teaching voice free from vocal stress.
- Because many schools offer adult learning activities and adult learning groups include persons with hearing loss, learning disabilities, and chronic illnesses.

WHAT ARE DESIRABLE ACOUSTICS?

Because of the high proportion of construction materials with a low acoustic absorption capacity, as well as the volume, sound generated from several sources reverberates (echoes) within the classroom. This causes a subsequent increase in the sound level (decibel), which is undesirable. This begs the question: What is desirable? Students need the following, according to "Classroom Acoustics II.":

- “An acoustic signal (the target spoken voice) that is at least 15 decibels (dB) more intense than the level of the background noise throughout the room.
- Overall sound levels (including the target speech plus noise) that are no greater than 70 dBA throughout the room, as measured using a sound level meter set to its A-weighted scale.
- Background noise that is less than 35 dBA throughout the unoccupied room.
- Sound absorbing materials such as acoustic tiles that minimize reverberation, resulting in reverberation times of less than 0.6 seconds in unoccupied classrooms."

GUIDELINES TO CREATING DESIRABLE ACOUSTICS

There are two guidelines for knowing what is required to create an acoustically pleasing school environment.

The first is the American National Standards Institute (ANSI) (www.ansi.org) standard S12.60-2002, Acoustic Performance Criteria, Design Requirements, and Guidelines for Schools, which establishes maximum levels of classroom noise and reverberation (ANSI). “The goal of this standard is to maximize the acoustics of classrooms so that all talkers in a classroom can be understood by all listeners in that room,” indicates “Classroom Acoustics II.” “This can be accomplished by reducing background noise to 35 dBA in an unoccupied room and by controlling reverberation time to a maximum of 0.6 seconds. When classrooms meet the ANSI S12.60 standard criteria, communication will occur at a clear signal-to-noise ration (SNR) of +15 dB (that is, the target speech signal is 15 dB louder than the background noise). In those classrooms, virtually all students and staff have full auditory access to the spoken language.”

The second guideline sets minimum acoustical requirements for schools being built to meet LEED certification. This guideline has three parts: HVAC background noise, exterior noise and reverberation time, as indicated by the U.S. Green Building Council (www.usgbc.org).

1 | HVAC BACKGROUND NOISE

Achieve a maximum background noise level of 40 dBA from heating, ventilating, and air-conditioning (HVAC) systems in classrooms and other core learning spaces,” according to the guideline.

2 | EXTERIOR NOISE

For high-noise sites (peak-hour Leq above 60 dBA during school hours), implement acoustic treatment and other measures to minimize noise intrusion from exterior sources and control sound transmission between classrooms and other core learning spaces,” according to the guideline.

3 | REVERBERATION TIME

For classrooms and core learning spaces that are less than 20,000 cubic feet the guideline notes: "Design classrooms and other core learning spaces to include sufficient sound-absorptive finishes for compliance with the reverberation time requirements specified in ANSI Standard S12.60–2010, Part 1, Acoustical Performance Criteria, Design Requirements and Guidelines for Schools…"

HOW TO CREATE DESIRABLE ACOUSTICS

The goal of classroom acoustical design is to ensure that the person speaking is as comprehensible as possible. "With a school, there are three prongs to acoustics," says Erik J. Ryerson, INCE, senior associate, acoustics, with Chicago-based Shen Milsom & Wilke LLC. "The first is acoustical separation of adjacencies, which is making sure there are appropriate boundary conditions and that floor/ceiling assemblies, etc., are designed to minimize sound intrusion from adjacent spaces. The second is interior acoustics, which is how sound behaves in the space, such as the reverberation or reflection of sound off the boundary elements of walls, ceilings and floors. Reverberation must be kept low or else it contributes to less-than-ideal speech intelligibility." Acoustic panels are often used in classrooms to keep reverberation times low. Panels must undergo tests in a reverberation chamber and be certified in order to prove their ability to perform well. Building owners are often misled to poor performing panels because of their low cost, thereby proving the adage you get what you pay for. "The third is background noise," Ryerson sums, "which is the noise within the space. It's most commonly about reducing noise from the HVAC equipment that serves the space."

Lets take a closer look at the solutions for all three prongs....

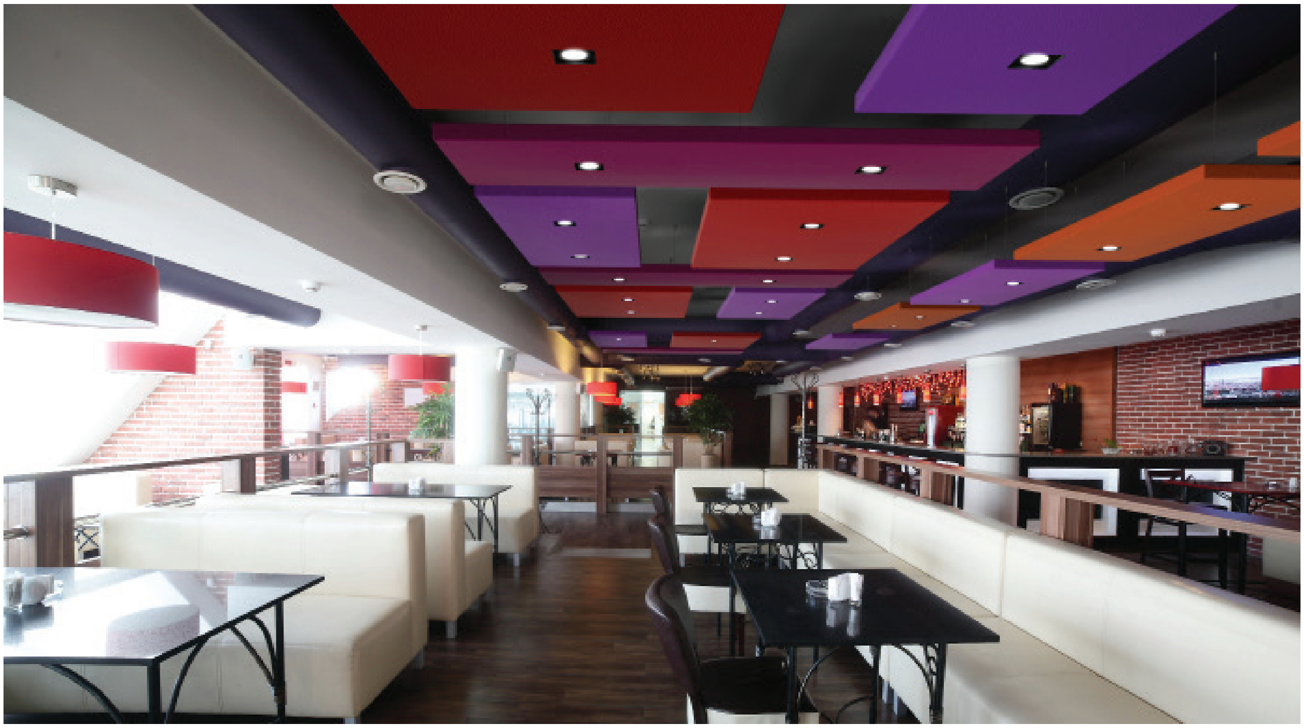
1 | ADJACENCIES

For separation of adjacencies, steel-stud partition walls, wood-stud partition walls and wood joist floor-ceiling assemblies all demand different components for optimum acoustic control.

- **Steel-stud partition walls:** "Light-gauge steel studs, typically used in walls, are acoustically resilient, so they reduce more sound energy transmission on their own than concrete or wood," says Stanley D. Gatland II, CertainTeed Corp., in an article titled "Understanding Acoustics and Sound Control," published on the American Institute of Architect's (AIA) Website (http://www.aia.org/practicing/awards/AIAB025071). "Air sealing always improves sound control, regardless of the structure involved. By adding sound-absorbing cavity insulation to a steel-framed wall, the sound performance of that assembly will greatly improve.

- **Wood-stud partition walls:** "As opposed to steel, wood studs are acoustically stiff, as sound transmits readily through wood," says Gatland. "Air sealing can significantly improve sound control. By adding cavity insulation, such as fiberglass, the STC can be improved …. A significant increase in acoustical performance can be achieved by mounting drywall to resilient channel and adding sound-absorbing cavity insulation."
- **Wood joist floor-ceiling systems:** "Wood joists are acoustically stiff, easily transmitting sound, so air sealing does improve sound control to an extent," says Gatland. "Wood joists have more mass and are typically deeper than wall studs. So, adding cavity insulation to this space limits the improvement … because of the inherent qualities of wood construction. A more significant increase in acoustical performance is achieved when sound-absorbing cavity insulation is used and the structural tie between the ceiling and the framing system is broken with a resilient channel or by using hanger wire."

Impact sound transmission – noise coming from upstairs – is also reduceable. Impact Insulation Class (IIC) test ratings apply to all floor-ceiling systems. "… since wood joists are acoustically stiff, air sealing will help with sound control," Gatland indicates. "The strong structural tie will transmit impact sound through the structure because the sound vibrations are physically entering the structure. So, adding cavity insulation limits IIC increases … due to that strong structural tie between the finishing materials and the frame. There is a significant increase in acoustical performance by mounting drywall to resilient channel and adding sound-absorbing cavity insulation.



2 | INTERIOR ACOUSTICS

One way to control sound is to use absorptive building materials and systems," says Gatland. "Design spaces to use a minimum of hard, sound-reflecting surfaces and install acoustical ceiling systems. Cover floor and wall surfaces with absorptive finishing materials, such as carpet, fabrics, and draperies. Isolate HVAC equipment and line duct work with sound-absorbing insulation.

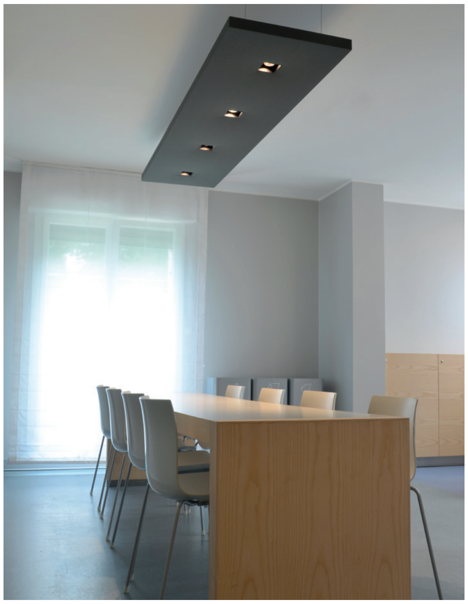
Acoustical ceiling-tile systems, especially those with fiberglass, are designed to help reduce reflected sound energy and are very effective at reducing overall room sound levels," Gatland continues. "Acoustical ceilings absorb rather than reflect airborne noise and improve conversational privacy in open spaces.

There is also a role for fiberglass and perforated metal panels, so consider hanging acoustical baffles with sound-absorptive properties, cover walls and ceilings in large open spaces. Fiberglass and perforated metal panels on walls are especially effective in high-ceiling areas, where a sound-absorptive ceiling will not be as effective."

-Stanley D Gatland II, Certain Teed Corp.
"Understanding Acoustics and Sound Control."

Finally, sound-absorbing panels are a common option. They reduce reverberation time, thereby increasing speech intelligibility. Panels are mounted to walls or ceilings or hung from ceilings. They also serve as dividers between desks that face one another or dividers between desks to make small group learning spaces.

"The consideration of adding an appropriate level of sound absorption products is driven by aesthetics and costs, and the quantity depends on the volume," Ryerson observes. Indeed, low-cost sound-absorbing products are known to perform poorly. As Ryerson indicates, the correct approach to achieving classroom comfort identifies the desired reverberation time, which indicates the quantity of panels required, which determines cost. Building owners must choose sound-absorbing panels that have been tested in accordance with International Organization for Standardization (ISO) (www.iso.org) 354 Acoustics — Measurement of sound absorption in a reverberation room to ensure a high-quality product that performs well.



3 | BACKGROUND NOISE

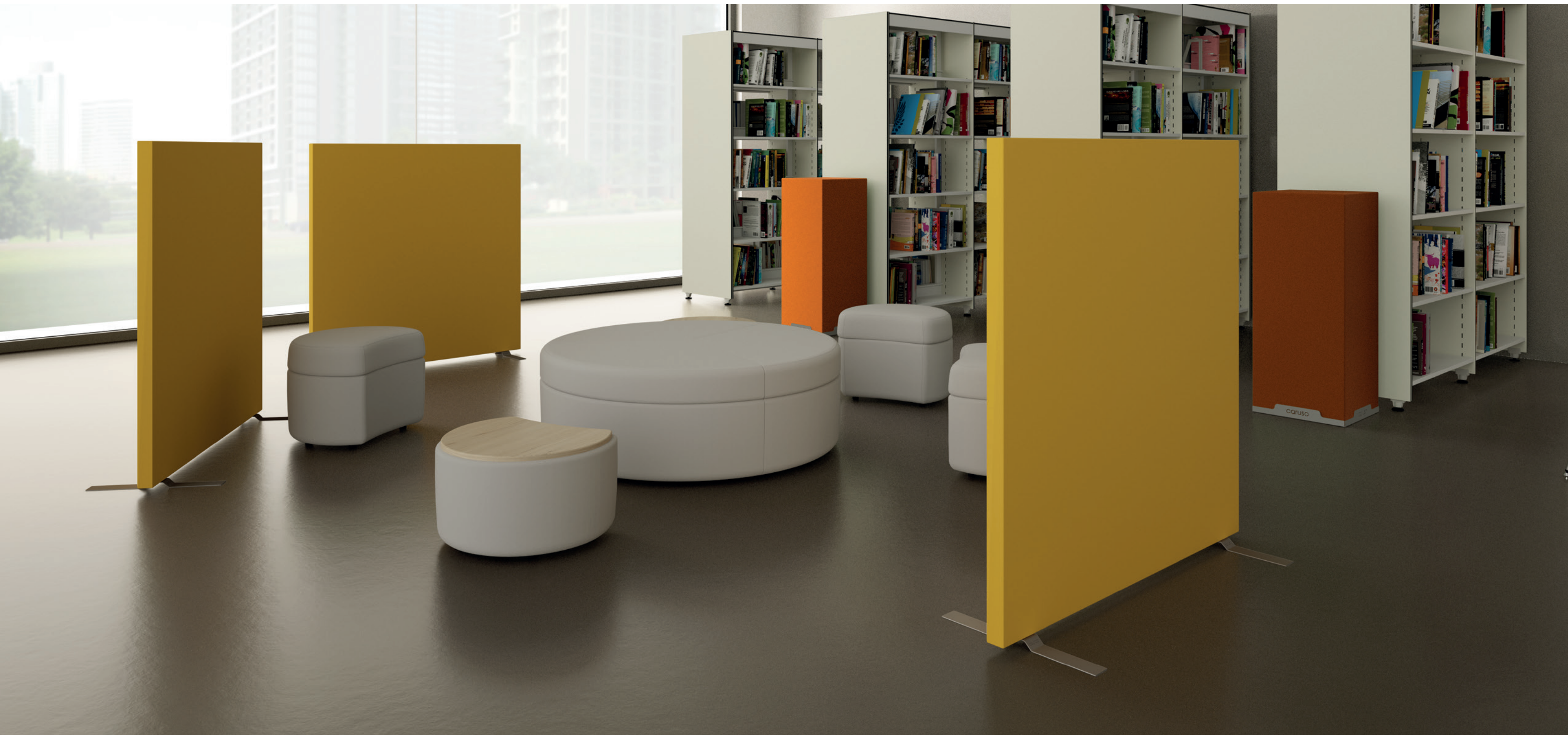
For background noise," says Ryerson, "sound from HVAC systems is reduced via duct liners and sound attenuation devices that reduce sound flow enough to meet a certain threshold for comfort and to encourage speech intelligibility within the space or privacy between spaces."

Like air and moisture, sound energy 'leaks' through paths of least resistance," adds Gatland. "Blocking above, between, and under [acoustical] partitions limits sound leaks for maximum sound control." Here are three ideas for stopping sound energy from flanking; there are many more.

- "Airtight electrical boxes block sound or can be air-sealed with caulking," says Gatland. "If possible, stagger the outlets so there is no direct path for sound. If that is not possible, block the direct path by creating a double stud wall and adding a gypsum board baffle."

- "Architects can design corners and T-intersections to be more acoustically beneficial," notes Gatland. "One way is to minimize direct contact between adjacent studs and staggering drywall joints. Gypsum board attachment: When using two layers of gypsum board, make sure that the board seams are staggered. Seams that are directly on top of each other can be efficient sound paths."

- "Plumbing and conduits can vibrate due to water movement and electrical energy," says Gatland. "Make sure mounting methods do not short-circuit acoustically isolated building elements. Mount plumbing and conduits directly to stud members with gasketed resilient hangers."



The best acoustics are achieved when it is taken into consideration during the design phase of a building and its rooms, Ryerson advises. It is expensive and time consuming to correct for acoustic comfort after construction is complete; however, it is possible. In such cases, conduct in-depth acoustic analyses and/or take measurements to determine the reverberation time in order to develop suitable solutions based on the activities being performed in each space. Count on an acoustical consultant to assist with both measurements and solutions.

The move to a collaborative teaching environment is bringing with it a change in classroom acoustics. With a little knowledge about sound and a little help from an acoustics consultant, it is possible to create acoustically beneficial school environments.

Acoustics and the Impact on

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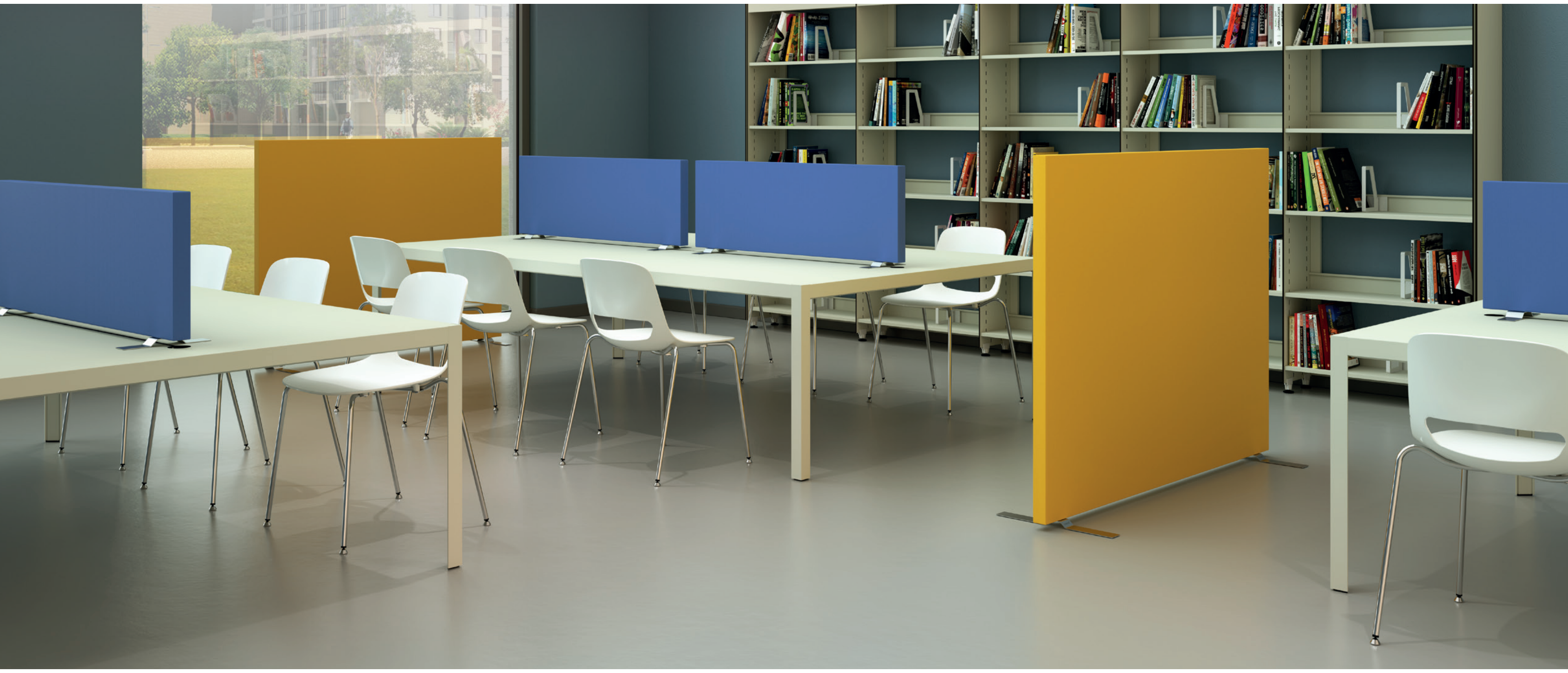

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"Minimum Acoustic Performance." **LEED. U.S. Green Building Council**. Web. 24 March 2016. Available from **http://www.usgbc.org/credits/schools-new-construction/v4-draft/eqp3.**

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FOR MORE INFORMATION:

There are a number of resources for additional information about sound control in building design. They include the following:

- Acoustical Society of America (ASA): acousticalsociety.org/
- "Classroom Acoustics I – A resource for creating learning environments with desirable listening conditions," A publication of the Acoustical Society of America: http://acousticalsociety.org/sites/default/files/docs/classroom_acoutics_1.pdf
- National Council of Acoustical Consultants (NCAC): http://ncac.com/
- ASTM E 1374, Standard Guide for Open Office Acoustics and Applicable ASTM Standards: http://www.astm.org/Standards/E1374.htm
- North American Insulation Manufacturers Association's (NAIMA) Insulation Institute: http://insulationinstitute.org/
- ANSI S12.60-2002, Acoustic Performance Criteria, Design Requirements, and Guidelines for Schools: http://webstore.ansi.org/RecordDetail.aspx?sku=ANSI%2FASA+S12.60-2010%2FPart+1+(R2015).
- LEED Minimum Acoustic Performance Requirement: http://www.usgbc.org/credits/schools-new-construction/v4-draft/eqp3