ASSOCIATION FOR LEARNING ENVIRONMENTS

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HEALTHY SCHOOLS BY DESIGN

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Healthy Schools By Design

While discussions regarding the capacity of learning environments to improve student health and learning outcomes have gained momentum in recent decades, the COVID-19 pandemic catapulted the importance and urgency of designing schools to promote and protect health. Now, many are asking, What makes a health-promoting or healthy school? What strategies should we target and prioritize to design healthy environments? This paper addresses the importance of healthy learning environments and suggests actionable design solutions to minimize disease transmission and promote health and well-being among students, staff, and administrators. It also provides guidance on how to apply the foundations of research-informed healthy schools to influence project designs, highlighting strategies for indoor air quality and ventilation, daylighting and views, and acoustics and noise reduction. Operations and maintenance are also discussed to ensure a well-designed learning environment supports the health and well-being of all occupants throughout the life of the space.

Why Are Healthy Schools Important?

The World Health Organization defines health as "a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity." Health remains the cornerstone of today's concept of wellness (WHO, 2005), with a holistic model of health encompassing the interrelationships between physical, mental, social, and environmental aspects of wellness. Thus, healthy environments play a critical role in promoting the health, well-being, and safety of all occupants while also minimizing disease transmission (Lee, et al, 2020).

A student's health, wellness, and ability to learn are impacted by the environments they spend time in. Over four decades of research confirms that school buildings are foundational to student success and impact their health, thinking, and performance (Allen, et al, 2017). A Harvard Healthy Buildings study estimated that students will have spent over 15,000 hours in school buildings by the time they graduate high school (Eitland, et al, 2017). Because children spend most of their time in preschool and K-12 settings, the quality of learning environments is a critical factor contributing to health and future success in life. In fact, providing a healthy environment for students may be as important as curating the appropriate curriculum. Designers must consider how design impacts young, developing students' physical health, including their respiratory, nervous, endocrine, and cardiovascular systems, as well as their mental well-being and social-emotional development.

A poorly built and maintained building negatively impacts students' overall health, thereby hindering their ability to learn. Comparatively, a healthy space, with appropriate ventilation, lighting, and acoustics can elevate students' learning experience and enhance their ability to

focus, retain new information, and be creative. Prioritizing students' physical and mental health when designing and operating a space can help reduce stress and improve cognitive performance, perceived safety, and feelings of equity and inclusion among students. With better environmental conditions, students are better able to focus and engage in their academic studies as well as social-emotional learning that takes place during the school day.

Given the impact of the COVID-19 pandemic, and the importance of viral transmission mitigation, it is more essential than ever to invest in the design of health-promoting school environments. Design, construction, operations, and maintenance strategies should be used to elevate the intent of the built environment to enhance the development, health, and safety of its occupants. We should strive to have the best possible impact on physical and mental health with the spaces we design.

Target Strategies, Design Features, and Policies to Prioritize

When defining target strategies for healthy spaces, designers should not only prioritize the design and construction of the space but also the operations and maintenance policies that will be implemented to address occupants' physical and mental health throughout the life of the space.

The Healthy Buildings team at Harvard T.H. Chan School of Public Health has synthesized 30 years of scientific evidence into nine building factors that are priorities for project design, operations, and maintenance improvements while also fundamentally influencing health and performance. Research evidence indicates that "The 9 Foundations of a Healthy Building" (Allen, et al, 2017) include:

1) Indoor Air Quality

2) Ventilation

3) Lighting & Views

4) Acoustics & Noise

5) Thermal Health

6) Water Quality

7) Safety & Security

8) Moisture

9) Dust, Pests, & Mold

How Can Design of Learning Environments Promote Health and Well-being?

The following sections will highlight design strategies for the first four foundations above (with Indoor Air Quality & Ventilation presented together) and will provide operations and maintenance suggestions that can help to ensure a well-designed learning environment promotes and protects the health and well-being of all occupants throughout the life of the space.

Indoor Air Quality & Ventilation

Indoor air quality can be affected by the air inside the space as well as the air coming in from the outdoors. The six most common air pollutants in the U.S., as outlined in the Environmental Protection Agency's national ambient air quality standards (NAAQS) include carbon monoxide, particulate matter (PM10 and PM2.5), ground-level ozone, sulfur dioxide, nitrogen dioxide, and lead. In classrooms, it is advised to control specific levels of certain indoor air pollutants, including particulate matter as well as volatile organic compounds (VOCs) and carbon dioxide (CO2), as they can have adverse effects on occupant health and student learning.

Studies show that poor ventilation can affect students' physical health and cognitive performance. Poor ventilation can also be associated with asthma symptoms, absenteeism, reduced attention span, and poorer performance on math and reading tests (Eitland, et al, 2017). For example, extended exposure to inhaled particulate matter pollution can have adverse effects on people with underlying conditions, children, older adults, and nonwhite populations (US EPA, 2022). To receive a good Air Quality Index Category rating (AQI), 12.0 micrograms or less is considered the safe range of PM2.5 in an average of 24 hours.

Furthermore, CO2 at certain levels begins to limit oxygen in a space, which will impact the occupants' cognitive performance, awareness, and reaction time. With high levels of CO2, occupants may also feel sleepy and have trouble concentrating. According to the American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) Standard 62.1, it is recommended that CO2 concentrations in an occupied classroom do not exceed 700ppm above the outdoor concentration (ASHRAE, 2020). Considering up to 90% of schools in the U.S. do not meet minimum ventilation standards, meeting and increasing the ventilation standard minimums is a great place to start with projects (Allen & Macomber, 2020).

Recommended Approach to Indoor Air Quality and Ventilation

As budget concerns remain at the forefront for school districts, there are affordable and attainable strategies for schools that may not have the ability to upgrade air systems and air monitoring systems throughout campus. Operable windows, window walls to the outdoors, and roll-up doors have gained popularity recently as many studies, articles, and experts tout the feasibility and effectiveness of utilizing an open window to ventilate a space. In addition to improving the air quality in a space, these strategies help move out harmful particles, including viruses, and they overlap with other healthy design strategies, like optimizing natural daylight, views to nature, and indoor-outdoor connection. Additional strategies for improving indoor air quality include increasing the

Operable windows offer natural ventilation, boosting the amount of outdoor air introduced into the building, while decreasing the load on HVAC equipment.

Project: South Tahoe High School
Location: South Lake Tahoe, CA

Roll-up doors to the outdoors optimize opportunities for fresh air, ample daylight, and access to green spaces.

Project: West Valley College – Che School of Professional Studies
Location: Saratoga, CA

number of air exchanges, ensuring the air is filtered properly, and implementing additional air-cleaning policies.

Strategies for improved indoor air quality should also involve consistent operations and maintenance policies and plans. To reach optimal ventilation for student health and learning success, designers should work with schools to go beyond the acceptable or minimum indoor air quality requirements. For example, while the ventilation standard for ASHRAE 62.1 recommends a minimum of three air changes per hour (ACH), increasing to six or more will improve the air quality in the space (ASHRAE, 2020). Sustainability rating systems, like WELL and LEED, grant credit to projects with enhanced ventilation, increasing ventilation to 30% above the minimum requirements of ASHRAE. This is an efficient strategy, as most buildings can increase their air changes with little cost impact. ASHRAE also recommends using air cleaners and/or filters that achieve Minimum Efficiency Reporting Value (MERV) 13 or better levels of filtration performance, which translates to a more efficient system that captures airborne viruses while also reducing PM2.5 (ASHRAE, 2020).

Operations & Maintenance Solutions for IAQ and Ventilation

1. **Increase ventilation: Boosts amount of outdoor air introduced into the building and the volume of air exchange per hour.**
2. **Include operable windows: Increases ventilation and air changes while decreasing the load on HVAC equipment.**
3. **Install CO2 and PM sensors: Smart systems alert occupants to close windows when outside air quality is poor or automatically turn on the air systems to exchange fresh air when CO2 or particulate matter levels are high in a certain space.**
4. **Upgrade filtering in air systems: Filter air entering the spaces from outside as well as recirculated air.**
5. **Use supplemental devices: Examples include portable air cleaners and/or window-mounted box fans with filtration attached. Box fans can also be pointed outwards to draw air to the outdoors.**

Daylighting & Views

Proper daylighting is another strategy that can create a positive domino effect resulting in multiple improvements. Natural sunlight in the day is otherwise called blue-enriched white light. One study showed that utilizing natural daylight in classrooms and exposing students to this blue-enriched light enhanced their alertness, concentration, cognitive processing speed, and test performance (Keis, et al, 2014). A report supported by the California Board for Energy Efficiency regarding daylighting in schools attested that proper daylighting significantly impacts students' academic performance, particularly on standardized math and reading tests. The study suggests the importance of increased windows and skylight areas in school buildings, as students in classrooms with the most daylighting progressed 20% faster on math tests and 26% faster on reading tests (Heschong, et al, 2002).

Higher illuminance levels in classrooms from increased access to natural daylight has also been shown to contribute to students' health, such as improving their quality of sleep, and reducing symptoms of headaches, depression, nearsightedness, and eyestrain (Harvard C-CHANGE, 2021). Ample natural daylight in a space likely indicates there are significant fenestrations (windows or openings) that not only offer access to natural daylight but also views to the outside world, which provide visual eye rest from focused activity and help sustain attention. One study found that less access to views of green space, like trees or other vegetation, was linked to higher rates of chronic absenteeism (Yin, et al, 2019), indicating the far-reaching implications of unhealthy learning environments.

Recommended Approach to Daylighting & Views

It is important to design classrooms and collaboration spaces that have access to natural daylight and offer views of outdoor spaces with ample landscaping and vegetation. Research recommends designing windows and openings with views to nature or physical access to the outdoors through roll-up or cantina doors, offering students access to daylight (and its many benefits) along with views to green space (e.g., woods or meadows) and/or blue space (e.g., lakes or rivers).

Daylighting & Views Design Solutions

1. **Install windows with views of outdoor vegetated spaces.**
2. **Design landscaping that enhances views without blocking daylight entering the space.**
3. **Avoid obscuring views with large furniture such as bookcases, cabinets, etc.**
4. **Add skylights or solar tubes to allow extra natural light deep into spaces or in an existing space with no daylight.**
5. **Design lighting systems to detect optimal natural light, adjusting artificial light when there is sufficient daylight in the space.**

Acoustics & Noise Reduction

The acoustic environment of a space has immense impact on a student's ability to learn and a teacher's ability to teach. Noise can be understood as any unwanted sound. If a classroom becomes too noisy or too distracting from noise, it can be difficult to hear or concentrate and may lead to increased stress and fatigue from trying to block out the unwanted sounds. Environmental noise exposure has also been linked to increased irritability, emotional symptoms, behavioral conduct problems, increased hyperactivity, higher blood pressure, and poorer well-being among students (Allen, et al, 2017).

Not only does increased noise hinder students' health and well-being it also contributes to poor academic performance. In fact, students may miss up to one in four words being spoken by their instructor due to poor room acoustics or sound intelligibility. Additionally, poor acoustics in schools showed that test scores were 5.5 points lower for each 10dB increase in noise level over the recommended 50dB preferred for a classroom setting (Pujol, et al, 2013). Because they are still developing mature language skills, children under age 15 are more sensitive to poor acoustics that fail to mitigate noise. Noise interference can impair their speech and listening comprehension as well as their concentration, understanding of verbal information, reading comprehension, and memory, highlighting the need for improved acoustics in learning spaces (Allen, et al, 2017).

Recommended Approach to Acoustics

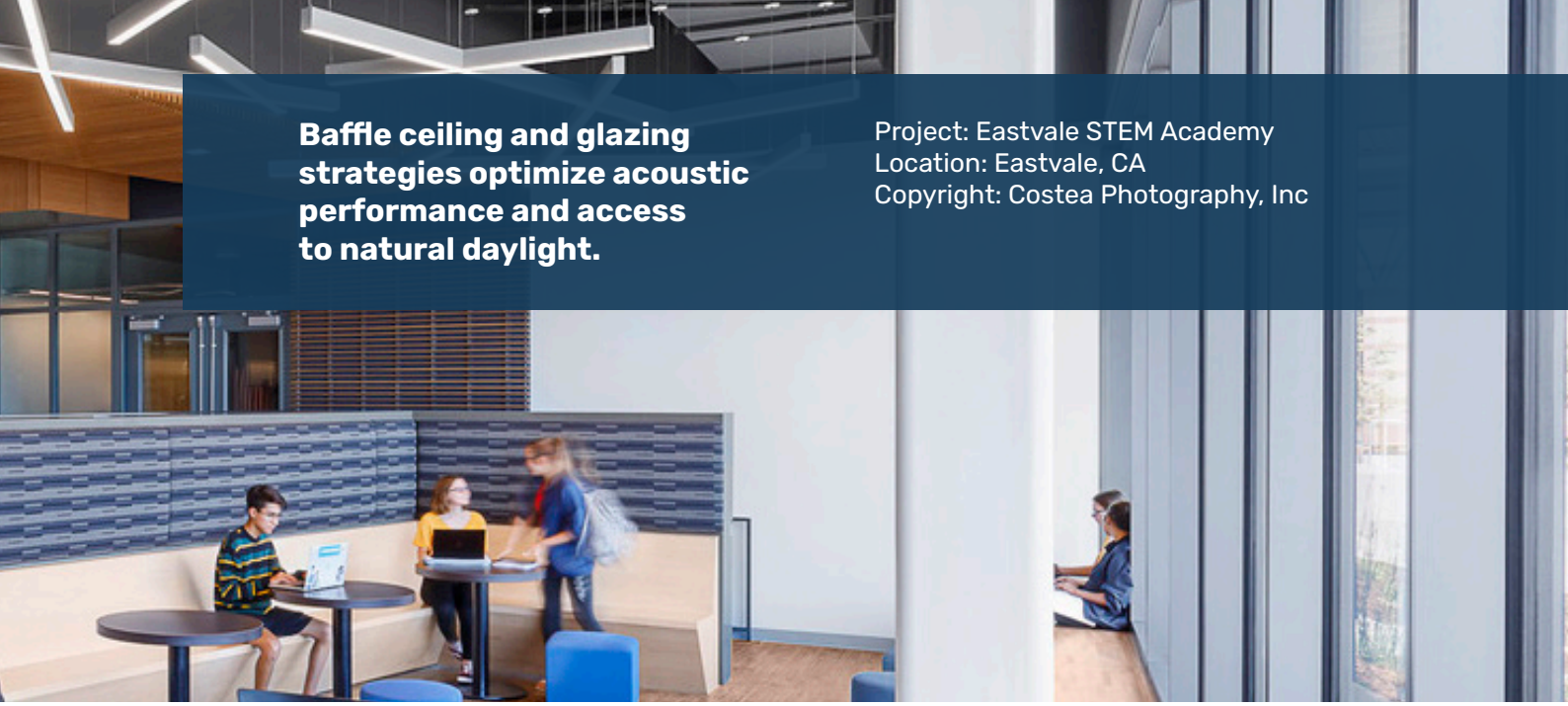
With acoustic performance and noise reduction in mind, design strategies include controlling or reducing HVAC background noise, reducing the reverberation time in spaces that have an echo or many hard surfaces, reducing transmission of noise from room to room or from outside to inside the learning space, proper maintenance upkeep, and selecting appropriate materials. Proper construction can also reduce sound transmission between spaces and/or from outdoors into the spaces.

Having operations and maintenance policies and procedures in place to assure HVAC systems are properly maintained is a critical factor in the acoustic performance of a classroom environment. HVAC systems that fall behind on maintenance can become noisy and distracting, filtration can be clogged, and they can leak which may lead to mold and contaminated air quality.

Selection of materials is another key factor in classroom acoustics. However, the need for material durability is sometimes at odds with good acoustic design. For example, learning spaces that offer collaborative, multifunctional and flexible spaces often have hard durable surfaces, like polished concrete floors. Similarly, spaces that provide abundant daylight and views through large windows generally reflect, amplify, or let sound pass through easier. Fortunately, thoughtful material choices and design strategies like those below can accommodate both durability and improved acoustics within learning spaces.

Acoustics & Noise Reduction Design Solutions

1. **Install double-pane windows.**
2. **Face windows away from high-traffic streets or noisy surroundings.**
3. **Stack similar spaces in multi-floor schools.**
4. **Design with various "zones" (e.g., smaller collaboration spaces where students and teachers can hear each other better).**
5. **Consider amplification technology for teachers to be heard throughout the room.**
6. **Include full-height partitions in classrooms to reduce sound transfer.**
7. **Install acoustic treatments, baffles, or drop ceiling systems that can reduce noise, and/or install sound absorbing wall panels and acoustic wall treatments.**
8. **Specify wall construction and doors that meet noise isolation class and sound insulation requirements.**
9. **Specify proper insulation between walls, ceilings, and roofs.**
10. **Install HVAC equipment on the roof and away from quiet spaces and focus-work classrooms.**
11. **Design interiors utilizing a mixture of textures and types of surfaces.**
12. **Incorporate flooring that absorbs sound.**



Baffle ceiling and glazing strategies optimize acoustic performance and access to natural daylight.

Project: Eastvale STEM Academy
Location: Eastvale, CA
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Barriers

A big challenge for schools in approaching these issues is that they are largely underfunded, and implementing improvements of natural ventilation, daylighting, and acoustics will often incur higher upfront costs. Although many schools are already struggling to manage budgets, there are direct implications on student success if this investment in healthy school design is not included in the list of priorities. A study by The Century Foundation identifies great inequities in communities of color primarily Black and Latina/o (TCF, 2020).

With underfunding as a challenge prior to COVID-19 and newly added operations and maintenance requirements handed down by the U.S. Centers for Disease Control and Prevention (CDC), there is an opportunity for federal infrastructure funding to positively influence the future health and performance of school districts and their students. The Century Foundation states that now may be a once-in-a-lifetime moment for schools across the United States to invest in healthy learning environments for the betterment of students' health and education (TCF, 2020).

Design Takeaways

When striving to create healthy learning environments, there are many design factors influencing health, and many strategies within each factor. Below are some of the key components of the top foundations of healthy schools, along with examples of related design strategies and research evidence for why it is important to be designing with these foundations in mind:

Indoor Air Quality

includes ventilation and filtration, as well as the operations and maintenance of air handling equipment and smart systems that sense and alert air quality issues. Healthy school design optimizes cognitive performance, concentration, and reaction time by including a well-maintained ventilation system that provides basic heating and cooling, with the option of natural or mixed-mode ventilation, when feasible. The operation and maintenance of HVAC should maximize positive occupant perceptions of thermal comfort and satisfaction with indoor temperature, air movement, and humidity.

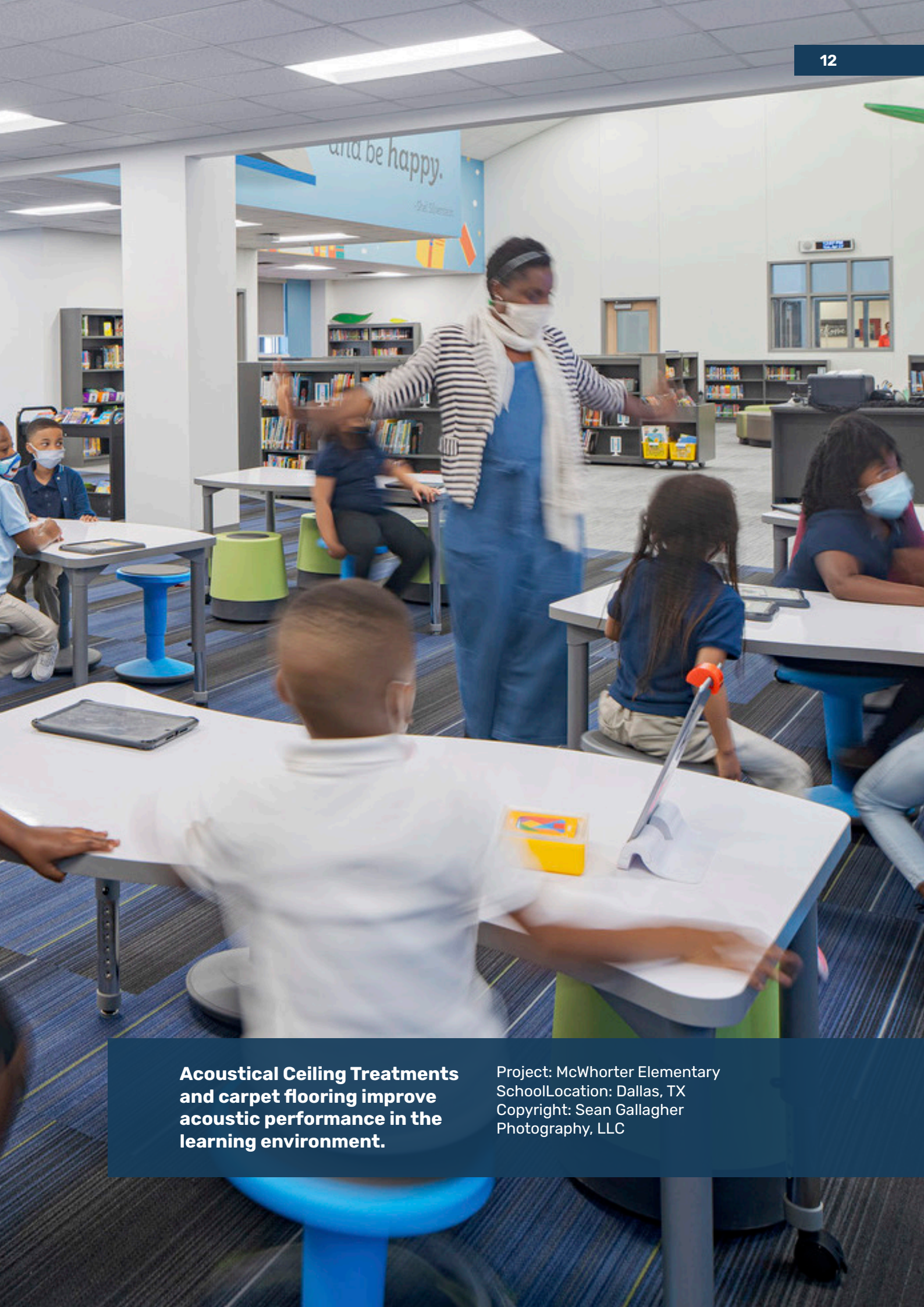
Daylighting

encompasses views and access to nature as one of many impactful biophilic design strategies. Healthy school design optimizes alertness, academic test performance, and sustained attention by incorporating ample daylighting, with user control of the amount of natural light, including minimized glare/ reflection as well as views to the outdoors and nature, and access to green space.

Acoustic Performance

depends on material selection and spatial arrangement as well as the maintenance and operation of equipment. Healthy school design optimizes sound intelligibility by reducing and mitigating unnecessary sound disturbances and distractions, reflected sound, and noise with sound absorption and isolation materials in ceilings, walls, and other areas.

With such complexity, designers should take a comprehensive, integrative approach to designing healthy environments that encompasses all aspects of design, construction, and stakeholder needs within each of these three categories.



Acoustical Ceiling Treatments and carpet flooring improve acoustic performance in the learning environment.

Project: McWhorter Elementary SchoolLocation: Dallas, TX

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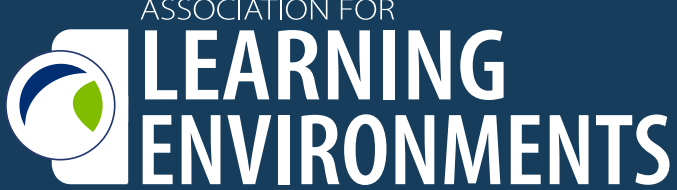
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