

Thermal Comfort in Schools



WorldGBC believes in green buildings for everyone, everywhere. Schools are no exception. We call for schools that are energy efficient, have low greenhouse gas emissions, and schools which are designed and operated for children's health, wellbeing and performance.

To help, Better Places for People has produced a series of briefing notes, focusing on four features of indoor environmental quality. These are intended for school board decision-makers, as well as school designers and facility managers, to share how design and operation features affect students' health and, in turn, their academic performance. By combining health, wellbeing and low carbon operation, we can ensure students spend their days in truly green school buildings.

PROBLEM:

Poor thermal comfort in schools can negatively affect children's health and academic performance.

PREVALENCE:



of schools in the Toronto District School Board have no air conditioning, which can help moderate temperature and humidity. **1**

SOLUTION:

Thoughtful school design and operation can improve thermal comfort and improve student health and performance. This can also most often be done without increasing greenhouse gas emissions.

What is thermal comfort?



Thermal comfort is a human's perception of comfort with respect to objective measures, such as temperature, humidity, and air velocity.

Factors affecting personal comfort include: **2 3 4 5**

- + Gender
- + Age
- + Race
- + Size
- + Weight metabolic rates
- + Insulation through clothing

Thermal comfort affects children's health and comfort



Children are more sensitive to higher temperatures

than adults because of their higher core body temperature and less developed thermoregulation capabilities. **6**



Higher humidity increased the rate of

Sick Building Syndrome symptoms in a study of over 1,000 Polish students. **7**



Respiratory complaints

were associated with "too hot" or "too cold" classrooms in a 2016 study of over 4,000 Finnish students. **8**

Thermal comfort affects children's performance at school



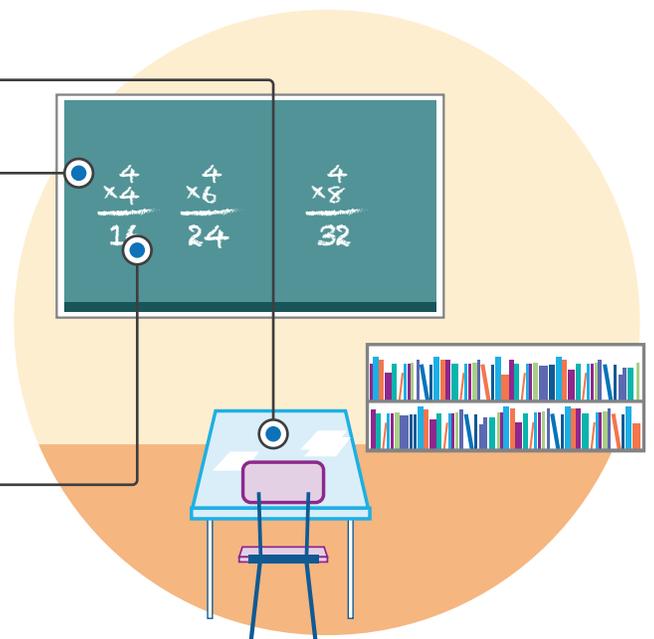
A study of 75,000 New York City students showed **a 0.2% decrease in test scores for every 1°F increase in temperature** **9**



Students citing their classroom as 'comfortable' **achieved 4% more correct answers** in a math test compared to those who were hot, according to a survey of more than 4,000 Finnish students **10**



Each 1°C decrease in classroom temperature showed a 12–13 point increase in math scores in a study of more than 3,000 US students **11**



A truly green school has good thermal comfort and low carbon emissions, achieved through:

- **Setting temperature points** to meet children's needs, as opposed to adults', which in colder climates, reduces energy costs associated with heating, as children prefer lower temperatures. **12**
- **Natural ventilation** from properly designed and placed windows, if appropriate for the climate and outdoor air quality, which can moderate the temperature and reduce energy needed for cooling and associated carbon emissions.
- **Energy-efficient and renewably-powered mechanical ventilation**, if necessary, which can provide a comfortable temperature and humidity level.

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Acoustics in Schools



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PROBLEM:

Poor acoustics in schools can negatively affect children's health and academic performance.

PREVALENCE:



of UK schools are adjacent to sources of external noise, including: 1



Motorways



Airports



Railways

SOLUTION:

Thoughtful school design and operation can improve acoustics and improve student health and performance. This can also most often be done without increasing greenhouse gas emissions.

What are acoustics?

Acoustics, or noise are typically measured using:

- + The **background noise level**, measured in decibel (dB)
- + **Reverberation time**, which measures the time a sound can travel in a room (a low reverberation time is desired to minimize echo and disturbances).



Acoustics affects children's health and comfort

Poor acoustics in classrooms can directly impact student health and behaviour: 2

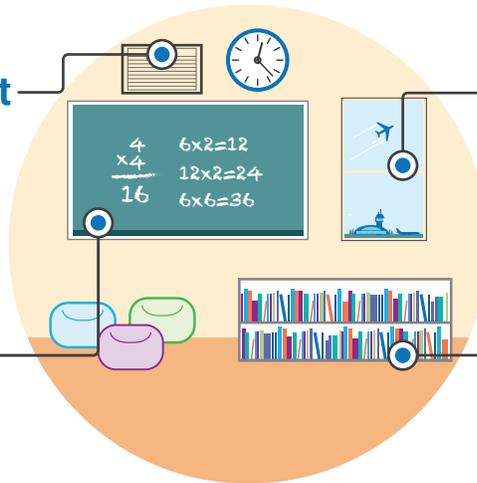


Acoustics affects children's performance at school

Internal sources of noise

↓ **Lower student achievement** scores were recorded in Florida schools with loud HVAC systems compared to students in quieter classrooms 3

✎ **For every 10-dB increase** in noise, the language and math scores of French students decreased by 5.5 points 4



External sources of noise

⋯ Students in a UK school located in a flight path misheard **1 in 4 words**, affecting language acquisition skills 5

↓ **Lower reading levels** were recorded in students located near a major New York airport 6 and London's Heathrow Airport, compared to those in a quieter location 7

A truly green school has good acoustics and low carbon emissions, achieved through:

- **Locating new schools** away from permanent external noise sources, which can improve acoustics and increase the option of using natural ventilation, where the climate allows.
- **Optimising insulation** in existing schools, which can reduce external noise and noises from internal sources outside the classroom and reduce energy cost.

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Indoor Air Quality in Schools



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PROBLEM:

Poor indoor air quality in schools can have a negative affect on children’s health and academic performance.

PREVALENCE:



More than 25 million children, nearly 50% of students in the United States, attend schools without an IAQ management plan. ¹

SOLUTION:

Thoughtful school design and operation can improve indoor air quality and improve student health and performance. This can also most often be done without increasing greenhouse gas emissions.

What is indoor air quality?

Indoor air quality (IAQ) is defined by the concentrations of various pollutants, including:

- + Carbon dioxide (CO₂)
- + Volatile organic compounds (VOCs)
- + Moulds
- + Dusts
- + Airborne fungi

Specific concentrations of these pollutants, as well as ventilation rates, have been linked to sick building syndrome (SBS).

What is Sick Building Syndrome?

Sick Building Syndrome is characterised by a number of symptoms, including: ²

- lethargy
- dry and itchy skin
- headache
- sore throat
- nasal stuffiness and dryness
- dryness, pain and itching in the eye

Children are more susceptible to SBS because they inhale more pollutants per body weight than adults, due to higher breathing rates. ³

Indoor air quality affects children's health and comfort



Indoor exposure to VOCs

has been associated with SBS symptoms⁴ in schoolchildren⁵



Elevated CO₂ levels

have been linked to symptoms of wheezing among children⁶



Low ventilation rates have been

associated with increase incidences of SBS⁷ and nurse visits⁸

Indoor air quality affects children's performance at school

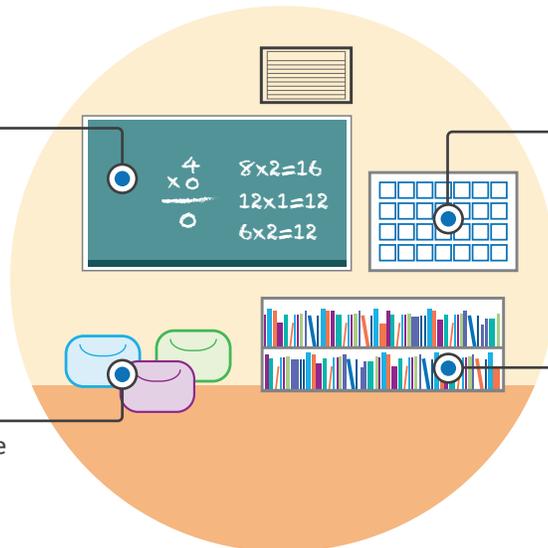
Examples of Positive Impact



In a study of 100 US elementary classrooms, there was a **2.9% and 2.7% increase** in math and reading scores, respectively, for each litre per second per person increase in ventilation rates⁹



Higher ventilation rates have been associated with faster and more accurate student responses for colour, picture memory and word recognition¹⁰



Examples of Negative Impact



A 1000 parts per million (ppm) increase above ambient levels of CO₂ has been linked to a **10-20% increase in days** away from school¹¹



Every 100 ppm increase in CO₂ was associated to roughly one-half day per year reduction in school attendance¹²

A truly green school has good indoor air quality and low carbon emissions, achieved through:

- **Natural ventilation**, when possible, which can refresh indoor air without increasing energy consumption, but this requires good outdoor air quality.
- **Hybrid or mechanical ventilation**, when needed, with appropriate filtration systems, which can be powered using on-site and/or off-site renewable energy to reduce overall carbon emissions.
- **Low or zero-VOC furnishings, materials and cleaning products**, which can help reduce baseline IAQ levels.

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Lighting in Schools



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PROBLEM:

Poor lighting in schools can have a negative affect on children's health and academic performance.

PREVALENCE:



of US schools are reported to have inadequate lighting. ¹

SOLUTION:

Thoughtful school design and operation through use of daylighting and energy efficient artificial lighting can improve student health and performance. This can also most often be done without increasing greenhouse gas emissions.

What is lighting?



Lighting in the built environment has two components:

- + Natural lighting from windows and skylights
- + Artificial lighting provided by electric lights

The balance between sufficient daylighting and artificial lighting requires the consideration of factors including:

- + Building design and orientation
- + Geographical location (climate and seasonality)
- + Heat loss or gain from windows
- + The need for particular task-lighting
- + Hours of operation of the school.

Lighting affects children's health and comfort



Children have higher sensitivity to light ²

because they have smaller pupils and less melatonin-suppression than adults, affecting their sleep/wake cycles and circadian rhythm ³



Daylight exposure in children

has been associated with reduced low-activity time and increased weekend physical activity ⁴



Blue spectrum LED light ⁵

in the morning could make children more stimulated ⁶ and alert at school compared to those exposed to dim light

Lighting affects children's performance at school



Significantly higher scores

and fewer typing errors were recorded on a computerised test for students under simulated daylight compared to artificial lighting ⁷



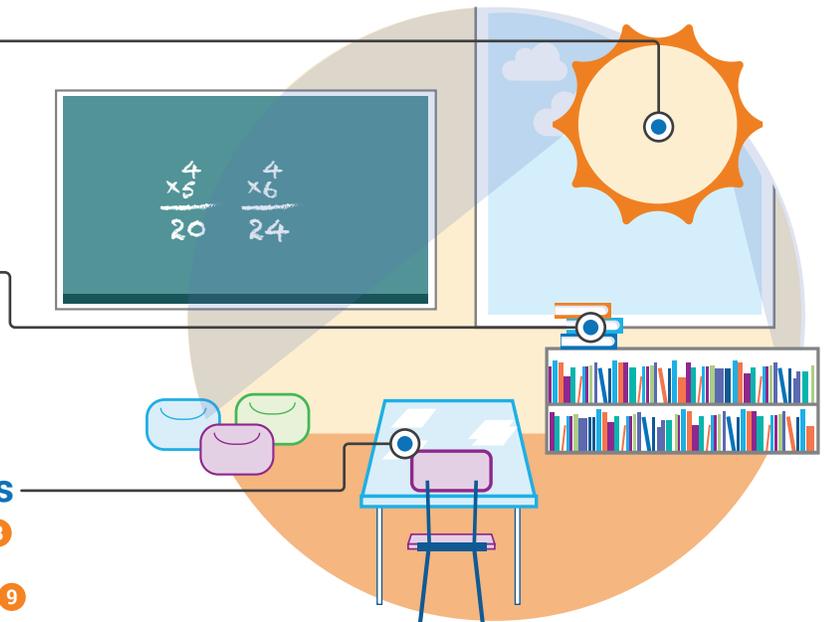
US students showed a 36%

increase in oral reading fluency when exposed to high-intensity light, while those in standard lighting conditions increased by only 16% ⁸



"At-risk" students showed larger gains

in oral reading fluency when exposed to high-intensity ⁸ light, compared to those in standard lighting conditions, and their improvement closely followed national trends ⁹



A truly green school has good lighting and low carbon emissions, achieved through:

- **Ample daylight**, which reduces the need for artificial lighting, thereby reducing overall energy use and carbon emissions. Heat gain/loss through windows must be managed.
- **The use of light emitting diodes (LEDs)**, especially those tuned to circadian rhythms, for artificial lighting needs. These lights use significantly less energy than older technologies, thereby reducing building energy consumption.

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