

Indoor Air Pollution: A Misunderstood Subject

The American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) is the source for all indoor air quality regulations. This organization is the leading professional society in the world, that deals with controlling indoor air and setting the *standards* that buildings operate under. They also make *recommendations*, which are not *standards*, and are not binding to local officials.

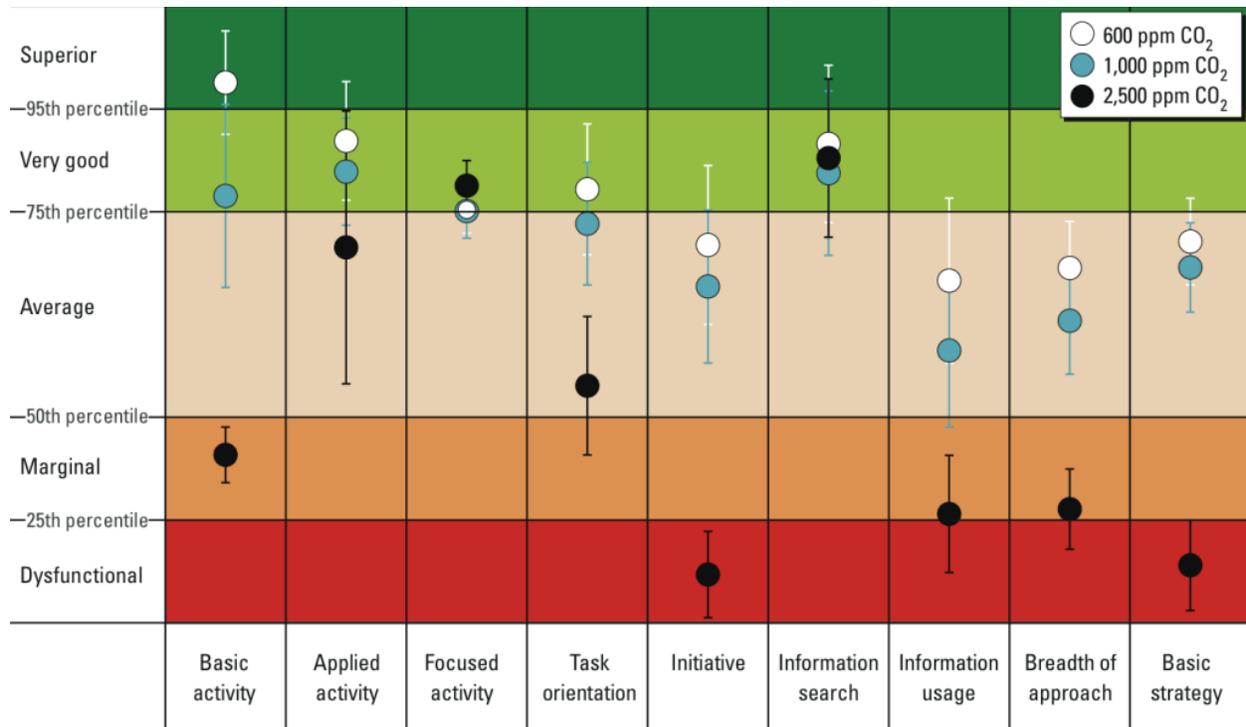
ASHRAE defines “healthy” as the inability of 4 out of 5 people in a room to detect the body odor of another person in the room. A *standard* was established to ensure this and is often incorporated into laws and building codes. The *standard* ASHRAE has set for carbon dioxide (CO₂) levels to be “healthy” in a room is 5,000 parts per million (ppm).

<https://www.ashrae.org/File%20Library/docLib/Technology/.../TC-04.03-FAQ-35.pdf>

But this *standard* has nothing to do with 'learning,' or how the brain functions with different levels of indoor air pollutants.

CO₂ is created in a building when people inhale oxygen rich air, use up the oxygen, and exhale CO₂. Therefore, crowded spaces or spaces with poor ventilation systems can have high and rising levels of CO₂ – which causes the brain to not work as well.

In the following graph, look at how our brains work in 9 different categories of mental activity, under 3 different levels of “healthy” air. Notice the dramatic difference in brain function between the white circles at 600 ppm of CO₂ and the black circles at 2,500 ppm of CO₂. As the graph clearly shows, 5,000 PPM of CO₂ is much too high a level for effective ‘learning’ to occur.



Startling Facts About Pollution in Schools

- 1 in 5 school systems tested by the EPA between 2012 and 2015 were found to have unsafe levels of lead in the drinking water.
<https://www.usatoday.com/story/news/nation/2016/03/17/drinking-water-lead-schools-day-cares/81220916/>
- A third or more of U.S. schools have serious mold, dust, and other indoor air problems.
<http://www.cnn.com/2012/01/14/health/school-indoor-air-pollution/index.html>
- The EPA estimates 1 in 5 American schools has a radon level requiring attention. Radon is the second leading cause of American lung cancer, right behind smoking.
<https://www.epa.gov/radon/radon-schools>
- Emerging scientific research indicates that indoor CO2 levels of 1000 ppm is the upper limit for effective learning in occupied classrooms.
<https://ehp.niehs.nih.gov/1104789/>
- Researchers have repeatedly found an increase in performance of between 5 and 17 percentile points when students study in non-polluted buildings.
<http://escholarship.org/uc/item/5sw56439#page-9>
- Students who attend schools in areas with outside air pollution fail standardized tests twice as often as students who attend schools with clean outside air.
<http://content.healthaffairs.org/content/30/5/852.full?related-rls=yes&legid=healthaff;30/5/852>
- 1 out of every 5 Americans either attends or works at a K-12 school.
<https://www.edreform.com/2012/04/k-12-facts/> and <https://census.gov/popclock/>
- There are currently no federal regulations to routinely inspect schools for pollution; only a dozen states have very modest requirements; the rest have none.
<http://www.cnn.com/2012/01/14/health/school-indoor-air-pollution/index.html>
- Studies show that one-half of our nation's 115,000 schools have problems linked to indoor air quality (IAQ).
- Indoor air pollution has been demonstrated to have an adverse impact on public health. Poor indoor air quality can cause short- and long-term health problems such as coughing, eye irritation, headaches, asthma episodes, allergic reactions, and in rare cases, life-threatening conditions such as respiratory distress. Improperly managed ventilation and filtration systems can contribute to airborne mold, infectious diseases, and carbon monoxide poisoning. Poor indoor air quality can also impact the comfort and health of children and staff, which can in turn affect concentration, attendance, and classroom performance.
 - Good indoor air quality can help ensure a healthier and higher performance learning environment for students and school staff.
- Indoor air can be two to five times more polluted than outdoor air and large populations of children might be more susceptible to indoor pollutants than the general population.

Additional Information and Resources at: <https://www.epa.gov/schools-air-water-quality/healthy-schools-and-indoor-air-quality>

Is CO2 an indoor pollutant? Well, there are direct effects of CO2 concentrations on human decision-making performance.

ASHRAE *recommends* that CO2 levels be held to 1,000 ppm. Unfortunately, it is not a legally binding *standard* - it is only a *recommendation* - and most buildings are not built to meet it.

See page 35 here:

https://www.epa.gov/sites/production/files/2014-08/documents/refguide_appendix_e.pdf

The primary way ASHRAE engineers keep a building “healthy” is to throw away used air and bring in fresh air. They do this by using fans to import around 15 cubic feet of fresh air for every room occupant per minute. If too little replacement air is pumped in, CO2 rises, and the experts are called in. But the experts work by the *standards* of a “healthy” building, not the *recommendations* of a building optimal for learning.

Many years ago, the U.S. Department of Defense studied environments like submarines and airplane cockpits. Armed forces members working in these enclosed spaces were observed making careless mistakes while learning, or while executing tasks they had successfully performed many times before. In such confined spaces CO2 levels rise, and the Defense Department found a direct correlation between these rising levels and the occupants’ ability to do their jobs. Mistakes rose when there was too little oxygen in the air, and conversely when the CO2 level was too high.

Furthermore, even if architects design a new school to ASHRAE *standards*, and the builders build it to ASHRAE *standards*, and people install air conditioning equipment that meets ASHRAE *standards*, you can still have a school where it is difficult for children to learn. No matter how hard the teacher works, or how many books the child has at home, or how attentive the parents are—if the CO2 level in a building is above 600 ppm, learning is impaired. And this is reflected in lower standardized test scores, and poor school reputations.

So, why would a school system ever have high CO2 levels? The answer is simple once you connect all the dots.

Energy is usually one of the largest expense categories for any school system, a very close second only to payroll expenses. The way many buildings cut energy costs is by slowing down the intake of fresh air and leaving a bit more already-conditioned air inside the building. This results in less hot or cold air from the outside that needs to be expensively treated, and energy bills go down, all while staying within ASHRAE guidelines.

But because school buildings continue to operate at the *standard* of 5,000 ppm, learning is impaired. We have seen that any indoor air above 600 ppm CO2 reduces learning. If you want to improve students’ ability to learn, then improve the indoor air quality.

The Pollution Detectives provide tools for you to measure indoor air quality. We may be able to lend those (or similar tools) to students so they can investigate their own learning environments.

Solutions: Here are some techniques that can be used to improve the amount of oxygen in the air of classrooms – some of which are low, or no cost. For those techniques that require more of a monetary investment, the rate of return often exceeds 20% annually – not including the increase in learning.

GETTING STARTED:

1. Ensure the school building has a functioning ventilation system.
2. Inspect the maintenance room for unsanitary conditions, leaks, and spills. Ensure the room is free of trash, chemical products, and supplies.
3. Establish and implement a regular schedule for inspecting and changing filters.
4. Ensure condensate pans are clean, unobstructed, and draining properly.
5. Establish and implement a regular cleaning schedule for air supply diffusers, return registers, and outside air intakes.
6. Check ground-level and roof intakes for pollutant sources (e.g., dumpsters, bus-idling areas, plumbing vents, and kitchen exhaust fans).
7. Ensure that ducts and the interior of air-handling units or unit ventilators are clean.
8. Keep unit ventilators clear of books, papers, and other items.
9. Ensure HVAC system settings fit the actual schedule of building use (including night and weekend use).
10. Educate teachers and school staff on the importance of keeping the HVAC system on to ensure classrooms are properly ventilated.
11. Use EPA's IAQ Tools for Schools program resources to identify, correct, and prevent indoor air quality problems.
 - o <https://www.epa.gov/iaq-schools>

KEEPING HEALTHY:

1. Perform regular HVAC system inspections and establish a HVAC maintenance plan.
2. Install high efficiency filters, if not already in use.
 - o ENERGY STAR for K-12 School Districts
 - <https://www.energystar.gov/buildings>
 - https://www.energystar.gov/ia/news/downloads/K-12_Challenge.pdf
 - o Take steps to ensure all rooms in the school building are ventilated.
 - o Ensure that air intakes are located away from high vehicular traffic areas, plumbing and exhaust stacks, and chimneys for the school's heating system.
 - o Install carbon monoxide detectors near combustion sources (e.g., boilers, stoves, hot water heaters, and vocational education shops).
 - o Ensure outdoor air ventilation meets or exceeds the industry's ventilation standard or local code.
3. Apply new air ventilation, cleaning, and filtration technologies, as resources allow (e.g., MERV 13 air filters and gas filtration media).
4. Apply the ASHRAE 62.1-2010 IAQ Procedure.
 - o <https://www.ashrae.org/standards-research--technology/standards--guidelines>
5. Develop and record measures specific to the school that will demonstrate improvement in HVAC system performance.
6. Engage students in classroom activities and projects that focus on indoor air quality.
7. Incorporate information and updates on indoor air quality into newsletters, school announcements, and other outreach material.

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