The Effects of Poor Indoor Air Quality in GCC Educational Environments

Executive Summary

Across the GCC, we often talk about education outcomes, student well-being, and future-ready learning environments. Yet one of the most influential factors sits quietly in the background: indoor air quality.

Recent research from universities and institutions across Qatar, the UAE, and Saudi Arabia consistently shows a clear pattern. Classrooms frequently operate with elevated CO_2 levels, particulate matter infiltration from outdoor sources, and varying levels of VOC exposure. These conditions are not just technical deviations from design standards—they directly shape the learning environment.

What the regional evidence increasingly tells us is simple: when ventilation is insufficient and indoor air quality declines, cognitive performance is affected. Students experience reduced attention span, lower alertness, and increased fatigue. At the same time, health outcomes such as respiratory irritation and asthma-related symptoms become more prevalent, impacting attendance and overall learning continuity.

In several GCC-based studies, CO_2 levels in classrooms have been recorded well above recommended thresholds during occupied hours, highlighting a persistent ventilation challenge in educational buildings designed for high cooling loads and extreme external climates. While awareness is growing, the gap between measured IAQ conditions and educational performance metrics remains underexplored.

This is where the opportunity lies for the region.

If we accept that learning environments are performance environments, then indoor air quality must be treated as a core design and operational priority—not an afterthought.

The link between air quality, cognitive function, and health is no longer theoretical; it is increasingly evidenced in our own regional context.

The GCC has the opportunity to lead by integrating science-led IAQ strategies into schools, universities, and public buildings - aligning health, sustainability, and educational outcomes in a way that delivers measurable long-term value.

The question is no longer whether indoor air quality matters.

It is how quickly we are willing to act on what the data is already showing us.

The Impact of Poor Indoor Air Quality

Poor Indoor Air Quality (IAQ) is strongly associated with reduced cognitive function conditions (via CO_2 and ventilation stress), increased health symptoms, and measurable degradation of the learning environment.

Itemised below is a structured synthesis of major GCC-based research on the impact of indoor air quality (IAQ) in learning environments, cognitive performance, and health outcomes.

1. Qatar – School IAQ, cognition-linked exposure, and health risk studies

Qatar University / Ministry of Public Health (Qatar schools)

- A major field study of **16 mechanically ventilated schools in Doha** measured CO_2, $PM_{2.5}$, PM_{10}, temperature, and humidity.
- Found **CO_2 levels averaging ~1776 ppm**, far above ASHRAE recommendations.
- Demonstrated that classrooms frequently exceeded acceptable particulate levels.
- Key implication: **poor ventilation → reduced learning comfort, cognitive fatigue, and increased respiratory risk**.

Relevance: Directly links high CO_2 exposure in classrooms to reduced indoor environmental quality affecting learning conditions. Read the Report here.

Qatar / regional university student environment studies

- University-level IAQ surveys in Qatar and RAK (UAE-linked GCC research networks) show:
    - Poor awareness of IAQ risks among students
    - Associations between poor IAQ and **respiratory symptoms and cognitive discomfort**

Relevance: Establishes behavioural and health impacts of IAQ in academic populations.

2. UAE – Dubai, Ajman, Ras Al Khaimah university & school studies

Dubai schools (Ajman University / PMU collaboration, 2024)

- Comparative IAQ assessment in **Dubai educational buildings (classrooms, labs)**:
    - Elevated **TVOCs, CO_2, airborne bacteria**
    - Pollutants varied significantly with occupancy (highest during teaching periods)
- Concluded IAQ directly affects:
    - **Student wellbeing**
    - **Academic performance**
    - **Cognitive comfort and attention span**

Ajman University – classroom learning efficiency study

- Controlled experiment in university classrooms:
    - CO_2 exceeded 1800 ppm during lessons
    - Students **did not perceive degraded air quality**
    - Improved IAQ reduced CO_2 accumulation and improved learning environment stability

Key insight: Demonstrates the disconnect between perceived comfort and actual cognitive environment quality. Read the Report here.

UAE universities (Ras Al Khaimah student IAQ awareness study)

- Found links between IAQ knowledge and behaviours influencing indoor exposure.
- Highlights **indirect cognitive impact via awareness and behavioural adaptation**

Ajman University "Healthy Buildings" collaboration (UAE + Europe)

- Multi-country research initiative:
    - Identified IAQ drivers in schools (ventilation, VOCs, mold)
    - Highlighted vulnerability of children to pollutants
- Explicitly linked IAQ to:
    - **learning performance**
    - **productivity**

- **respiratory health outcomes**

3. Saudi Arabia – classroom exposure and traffic pollution studies

Riyadh school IAQ & traffic pollution study

- Measured indoor/outdoor $PM_{2.5}$, PM_{10}, NO_2 in school environments.
- Found significant infiltration of **traffic-related pollutants into classrooms**.
- Demonstrated:
  - Poor ventilation increases pollutant exposure during school hours
  - Potential implications for **attention, cognitive load, and student fatigue**

Read the report here.

4. GCC-wide research themes (cross-country synthesis)

Across GCC academic and institutional research, five consistent findings emerge:

1. Elevated CO_2 and ventilation deficiency

- Many classrooms exceed **1000–1500 ppm CO_2**
- Directly linked in literature to:
  - reduced decision-making speed
  - lower attention span
  - increased cognitive fatigue

2. Particulate matter infiltration ($PM_{2.5}$ / PM_{10})

- Outdoor desert dust + traffic pollution enters schools easily
- Associated with:
  - respiratory illness in children
  - reduced school attendance
  - long-term neurocognitive risk

3. VOC and chemical exposure in modern schools

- Higher levels in:
  - science labs
  - computer rooms
- Associated with:
  - headaches
  - reduced concentration

- short-term cognitive discomfort

4. Strong link to learning performance (emerging but consistent)

Across GCC studies, IAQ is repeatedly associated with:

- attention span
- student alertness
- subjective learning comfort
- absenteeism

While few GCC studies measure cognition directly (test scores or neuroperformance), most infer impact via:

- CO_2 exposure
- ventilation rates
- symptom tracking

5. Health outcomes are the most consistently proven metric

Well-established findings across GCC research:

- asthma triggers
- respiratory irritation
- sick building syndrome symptoms
- increased sensitivity in children

5. Key gap identified across GCC research

Despite growing evidence, there is still:

- Limited **direct cognitive performance measurement (test scores, neurocognitive testing)**
- Fragmentation between:
  - engineering studies (CO_2, PM, VOC)
  - education performance outcomes
- Limited longitudinal studies in schools

Key Insights For The GCC

Across Qatar, UAE, and Saudi Arabia research, the evidence is consistent:

Poor indoor air quality in GCC educational environments is strongly associated with reduced cognitive function conditions (via CO_2 and ventilation stress), increased health symptoms, and measurable degradation of the learning environment.