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Using Low-Cost IEQ Sensors to Improve HVAC Efficiency and Reduce Operational Carbon

Why Indoor Environmental Quality Matters

Indoor Environmental Quality — or IEQ — has a measurable impact on health, comfort, cognitive performance and productivity.

Nevertheless, **today's monitoring systems are typically expensive**, bulky, and often measure only one parameter at a time. This **creates a major barrier to widespread monitoring** in schools, labs, offices and healthcare settings.

Recent academic literature reinforces this**: low-cost sensors can massively expand monitoring coverage**, but **accuracy, drift, and cross-sensitivity remain challenges** that require thoughtful validation and calibration.

Low-Cost Multi-Sensor IEQ System

To address these gaps, we **developed a modular, low-cost IEQ monitoring prototype** integrating:

- BME680: temperature, humidity, pressure,
- VOCsBH1750: light intensity
- LM358 sound module: loudness
- GP2Y10 + SPS30: particulate matter including PM2.5
- Using an Arduino MKR1010 with real-time clock for timestamps

(a) BME680 - Temp; (b) LM358 - Sound; (c) BH1750 - Light; (d) GP2Y10x - Dust; and (e) SPS30 - Particle sensors

This system was designed to be **affordable, compact, and scalable**, aligning with broader trends identified in current sensor research, where **low-cost frameworks combined with IoT platforms** are becoming viable solutions for **reliable indoor sensing.**

It has been **calibrated** the sensors **against commercial reference instruments** and deployed the system in two real conditions:

- Overnight office environment
- A concrete laboratory with high dust and activity variation

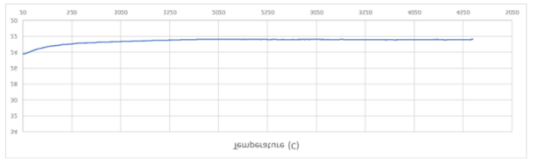
What We Found

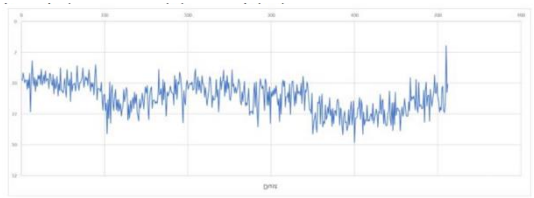
In an office environment, the system captured:

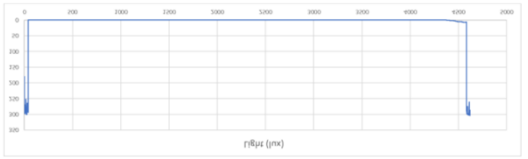
- predictable cooling cycles overnight
- sunrise illumination changes
- VOC increases after reduced ventilation
- small but detectable human-activity noise events

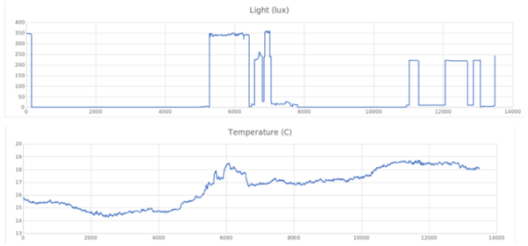
In a concrete laboratory, we observed:

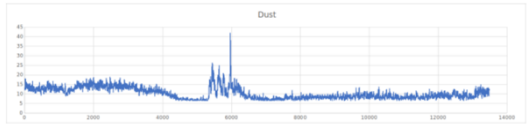
- clear PM2.5 spikes during material handling
- humidity and noise increases aligned with occupancy
- high sensitivity to rapid IEQ fluctuations
- strong agreement with reference instruments











Together, **these results show that low-cost MEMS-based multi-sensor systems can provide stable, meaningful IEQ insights at a fraction of the cost of traditional devices** — confirming trends highlighted in recent scientific reviews.

Why This Matters and What Comes Next

For industry partners, this approach supports **scalable IEQ monitoring, predictive maintenance, and more responsive building management**.

For academia, it offers a **research-ready platform for studying multi-factor comfort**, rather than treating temperature, noise, or IAQ as isolated variables.

Future work focuses on:

- advanced calibration methods
- sensor fusion and comfort modelling
- machine-learning-based drift correction
- activity-specific suitability analytics for classrooms, labs, and healthcare settings

This prototype shows that **IEQ monitoring doesn't have to be expensive — and that widespread multi-sensor insight is now within reach.**

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THANK YOU!
Q & A

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