



Uticaj temperature i kvaliteta vazduha na rezultate rada đaka u školama

Thermal and air quality effects on the performance of the schoolwork by children

4 December 2014

What is Swegon Air Academy?

- Exchange the knowledge
- Seminars
- Paper articles
- Literature



SAA, spreading knowledge about our indoor environment so we might make better decisions as HVAC professionals.

Thermal and air quality effects on the performance of schoolwork by children

The work and presentation material of David Wyon and Pavel Wargocki.

www.ie.dtu.dk

How many hours of schooling?

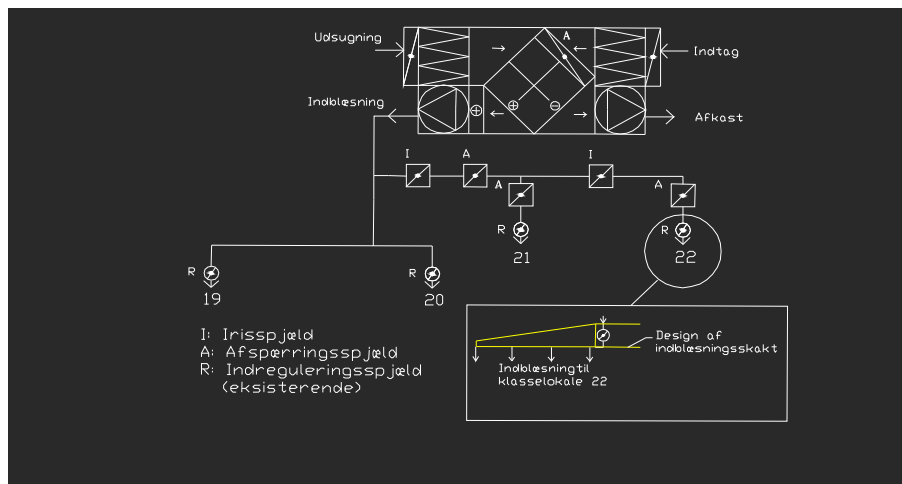
Field intervention experiments by DTU under ASHRAE 1257:

To determine whether improving classroom air quality and ensuring classrooms do not become warm can improve the performance of schoolwork by children.

Window opening behaviour was passively recorded during the experiments.

Method: Ventilation

- Indoor air quality was modified by increasing the outdoor air supply rate from an existing mechanical ventilation system



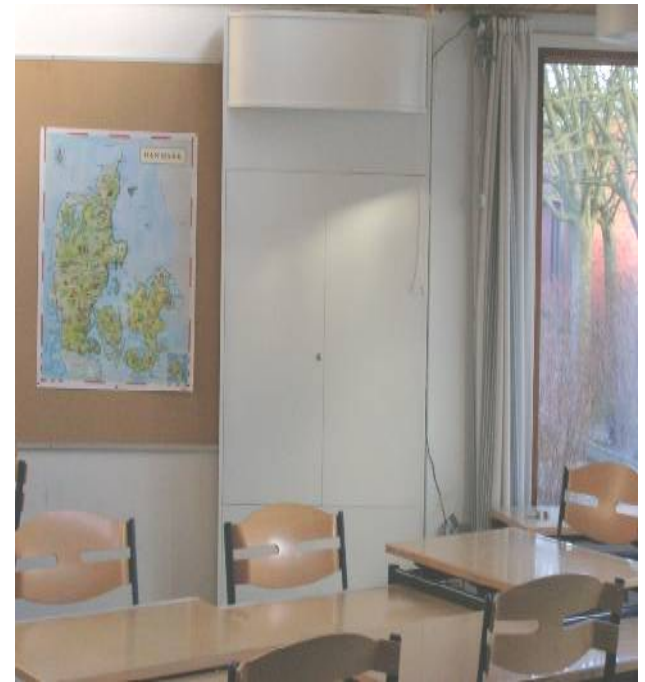
Method: Temp control and filtration

·Air temperature was reduced in hot weather by installing & operating split cooling units

Split cooling



Electrostatic air cleaners



Method: windows and doors

- Windows could be opened as usual.
- Window opening behavior was recorded as "All windows closed" or "1 or more open".
- Door opening was also recorded.

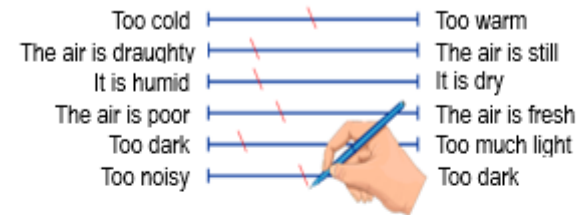
Physical measurements

- Continuous measurements (with pupils): CO₂, Air T, RH, window opening state recorders.
- Effective outdoor air supply rate in L/sp was estimated from CO₂ rate of increase each time children entered the classroom. Note that this includes air entering through windows or doors as well as supply air from the ventilation system.

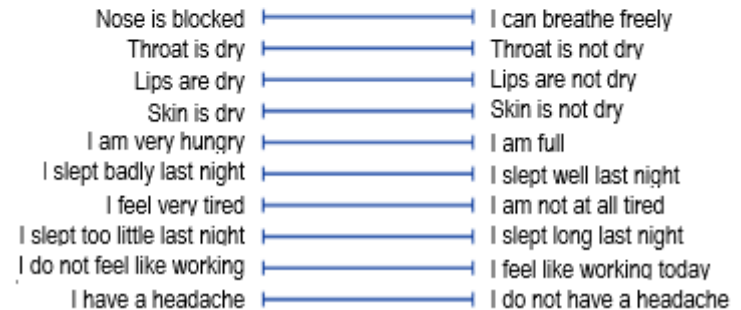
Measurements of perceptions and symptoms

- The children marked Visual-Analogue scales at the end of the week.
- They reported the:
- Classroom environment.
- Intensity of the symptoms they experienced.

How is the classroom right now?



How do I feel right now?

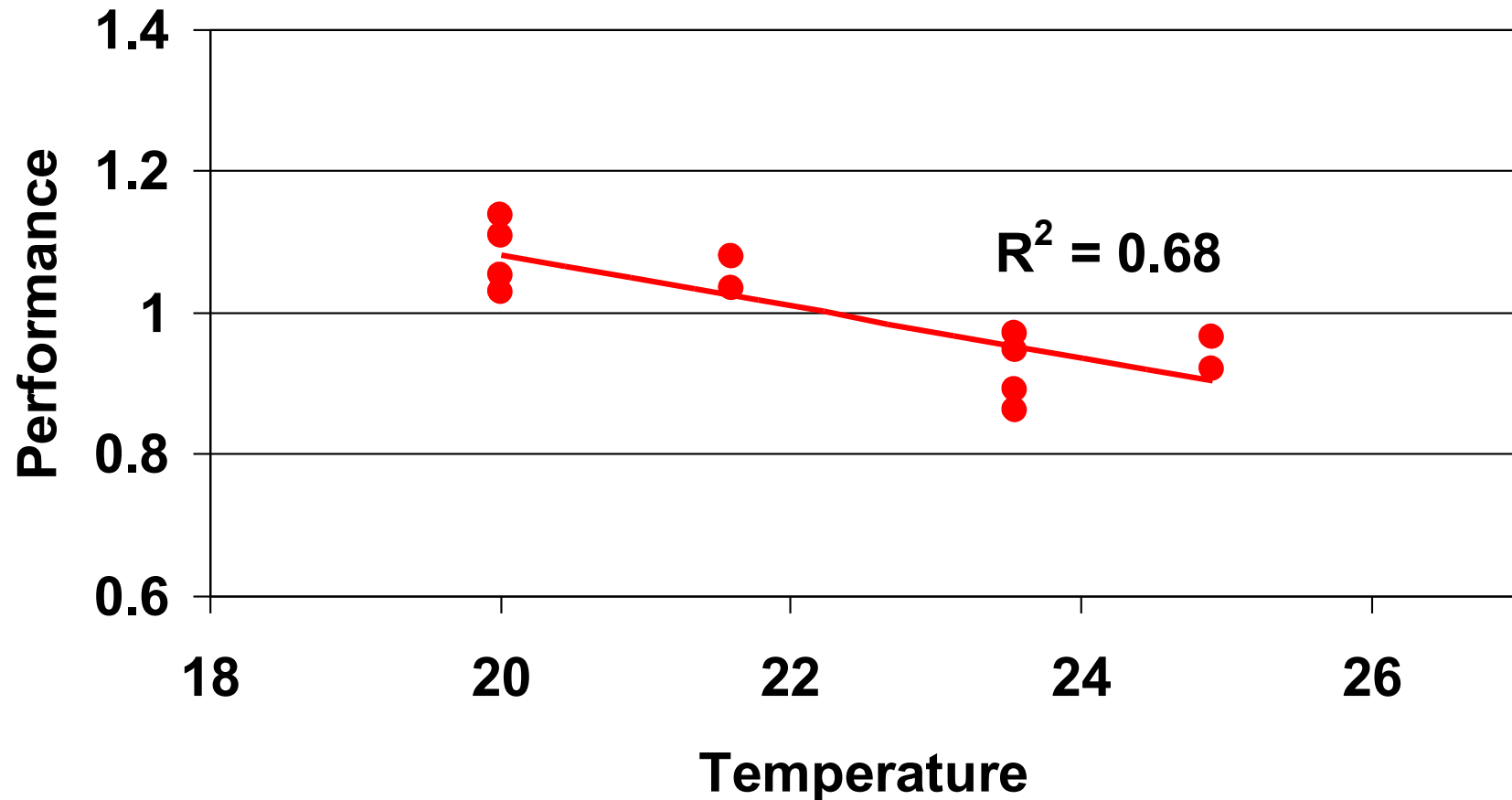


Measurements of performance

- Tasks appropriate to children's age were developed in consultation with class teachers
- 4 language-based:
 - Acoustic proof-reading
 - Reading and comprehension
 - Logical reasoning
 - Proof-reading
- 4 numerical:
 - Subtraction
 - Multiplication
 - Number comparison
 - Addition

Tasks were performed in mathematics or language lessons.

Performance of schoolwork as a function of classroom temperature



1oC lower temperature ~3.5% higher performance

Earlier experiments by DP Wyon in Sweden in 1967

- Raising classroom temperature from 20°C to 30°C reduced most types of schoolwork performance by up to 30%.
- For 40 years this was widely believed to be an overestimate.
- The present results confirm the size of the thermal effect first reported in 1967: +10°C would lead to 35% less schoolwork.

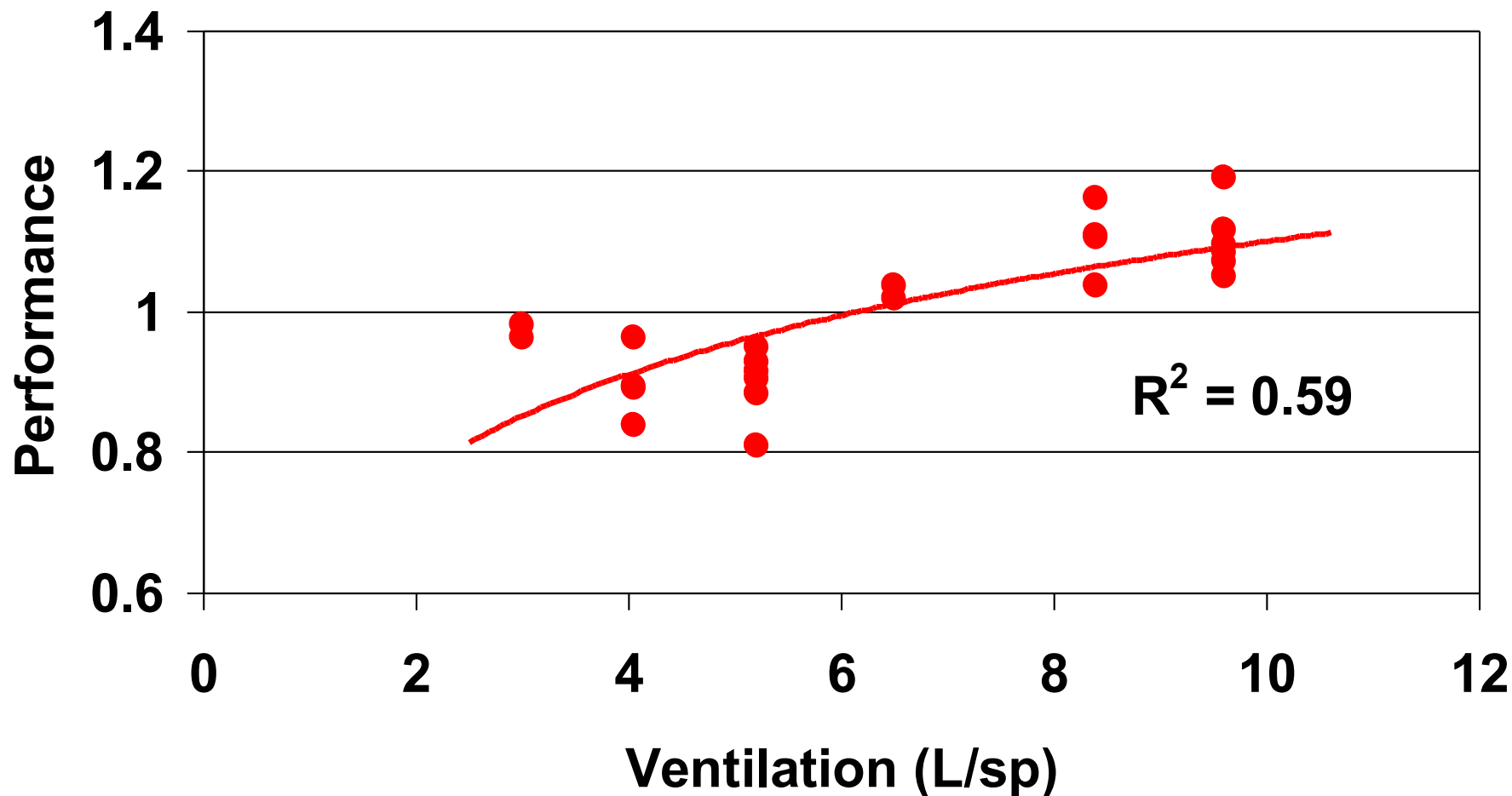
Increased outdoor air supply rate

Three independent field intervention experiments with 100% outdoor air supplied through new filters:

1. 3.4 was increased to 9.5 L/sp
2. 3.0 was increased to 6.5 L/sp
3. 5.0 was increased to 9.5 L/sp

(with and without cooling)

Performance of schoolwork as a function of classroom ventilation



Doubling ventilation rate \sim 14.5% higher performance

Classroom air quality matters

- Windows are often not opened.
- Outdoor air supply rates are often low.
- CO2 levels are often above 1000 ppm.
- Increasing the air supply rate from 2.5 to 5 to 10 L/sp – would improve the performance of schoolwork by 29%.
- Poor air quality is a major disadvantage for children, and especially for slow workers.

CO₂ in 1663 Scandinavian classrooms – October 2009

Table 3. The percentage of classes exposed to CO₂ concentrations above the recommended limits 1000 ppm, 1200 ppm and 2000 ppm in Denmark, Sweden and Norway for the three types of ventilation.

		Classes exposed to CO ₂ concentrations above the recommendations [%]		
		Natural	Exhaust	Balanced
Denmark	1000 ppm	69	51	37
	1200 ppm	64	43	26
	2000 ppm	30	16	3
Sweden	1000 ppm	47	38	12
	1200 ppm	33	31	6
	2000 ppm	7	13	1
Norway	1000 ppm	48	30	10
	1200 ppm	44	17	8
	2000 ppm	7	13	2

Main 1257-RP conclusions

- Reducing even slightly warm classroom temperatures eliminated thermal discomfort and improved children's performance.
- Increasing outdoor air supply rate improved classroom air quality and children's performance.
- Schoolwork was performed faster, with no increase in errors, in both cases.

Implications

- Removing airborne particles had no effect, so the IAQ effects were due to gas-phase pollutants in classroom air.
- Replacing supply air filters had no effect but increasing the outdoor air supply rate did, so pollutants must originate indoors.
- The active pollutants could be bioeffluents or emissions from materials, or both.

Conclusions on window opening

- Windows were opened to reduce classroom temperatures, not to improve IAQ.
- Natural ventilation did not ensure adequate ventilation, even with cross-ventilation.
- Split cooling, by eliminating the perceived need to open windows, decreased the air quality still further.
- Both slightly raised T and poor IAQ decreased children's performance.

SOLUTIONS

(In order of first cost and sophistication)

- CO2 sensor signals windows open/close.
- Computer operates windows optimally.
- CO2 controlled by variable exhaust flow.
- Balanced 100% fresh air supply + exhaust.
- Pre-heat supply air and remove ozone.
- Recover heat from exhaust airflow.
- Remove pollutants from return air using a desiccant wheel purged with outdoor air.

The Swegon Air Academy webinar series with Professor David Peter Wyon

Webinar 1:

Thermal and air quality effects
on the performance of the
schoolwork by children

Webinar 2:

Thermal and Indoor Air Quality
Effects on the Performance of
Office Work

www.swegonairacademy.com

How many hours?

Can we afford not to do something about this?

