

Pawel Wargocki

Technical University of Denmark, PAW@BYG.DTU.DK

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# PRODUCTIVITY IN SCHOOLS

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Pawel Wargocki

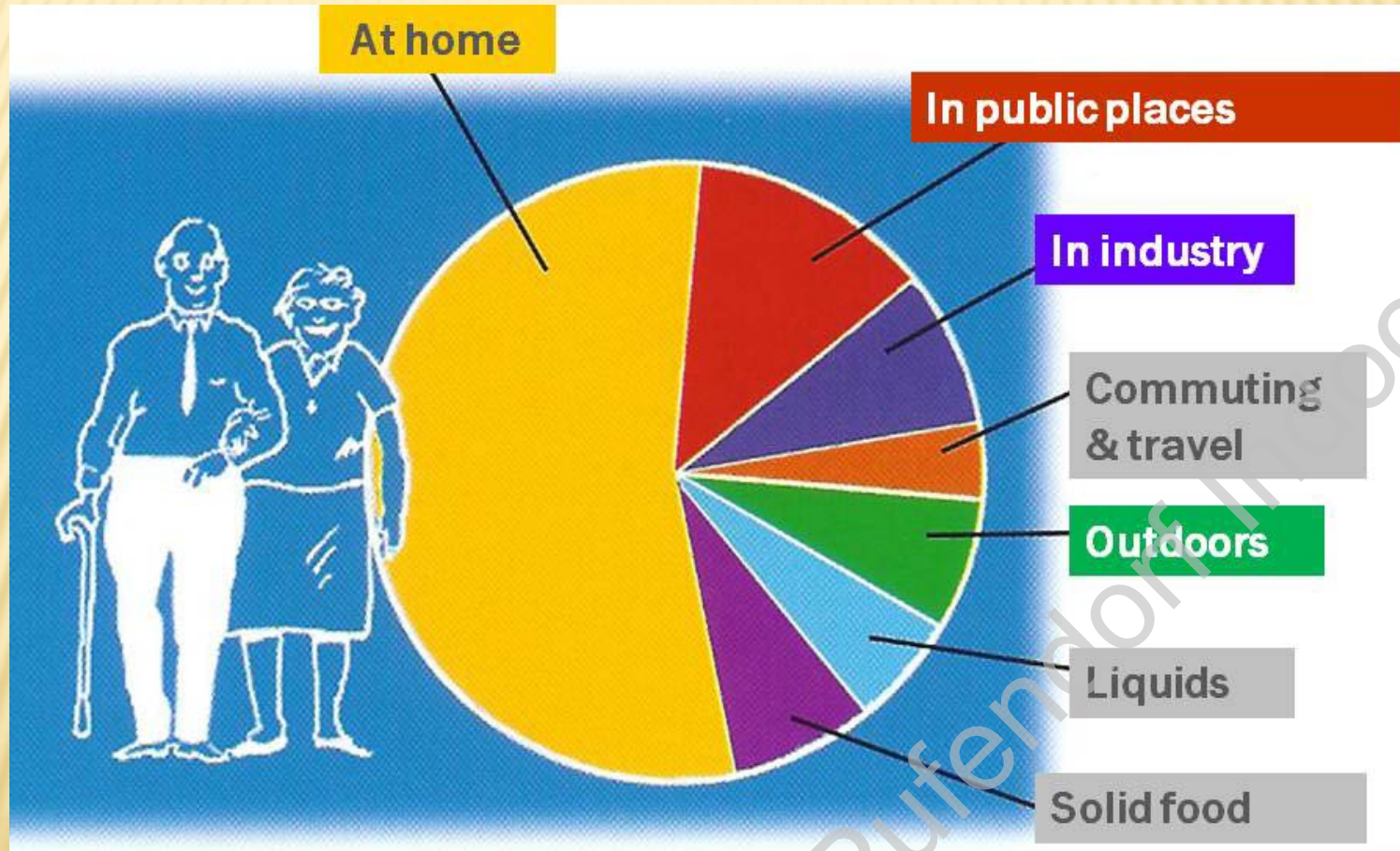
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# **EFFECTS OF INDOOR CLIMATE (AIR QUALITY) IN SCHOOLS ON LEARNING ABILITIES AND ACADEMIC ACHIEVEMENTS**



# INDOOR AIR IS SIGNIFICANT CONTRIBUTOR TO LIFE-TIME EXPOSURES



# IAQ IN SCHOOLS IS IMPORTANT

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- 20% of EU's population
- 20% of time in schools
- Children must attend school; they can not absent themselves or find another school
- The work that children are obliged to perform in schools is not optional and almost always new
- Children have far fewer ways of registering complaints
- The effects of IAQ/IEQ on children are likely to be more marked than for adults as children are more vulnerable and their bodies are still growing



# SCHOOL ENVIRONMENT IS SPECIAL

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- Children (pupils) and adults (teachers and other personnel)
- Occupancy is higher in classrooms than in other buildings (offices/dwellings)
- Teaching is carried out in groups (classes) with low area/volume per person
- There should be as least as possible distraction during teaching

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*A good education system constitutes one of the fundamentals of a modern society, because poor learning can have lifelong consequences for a student and for society*

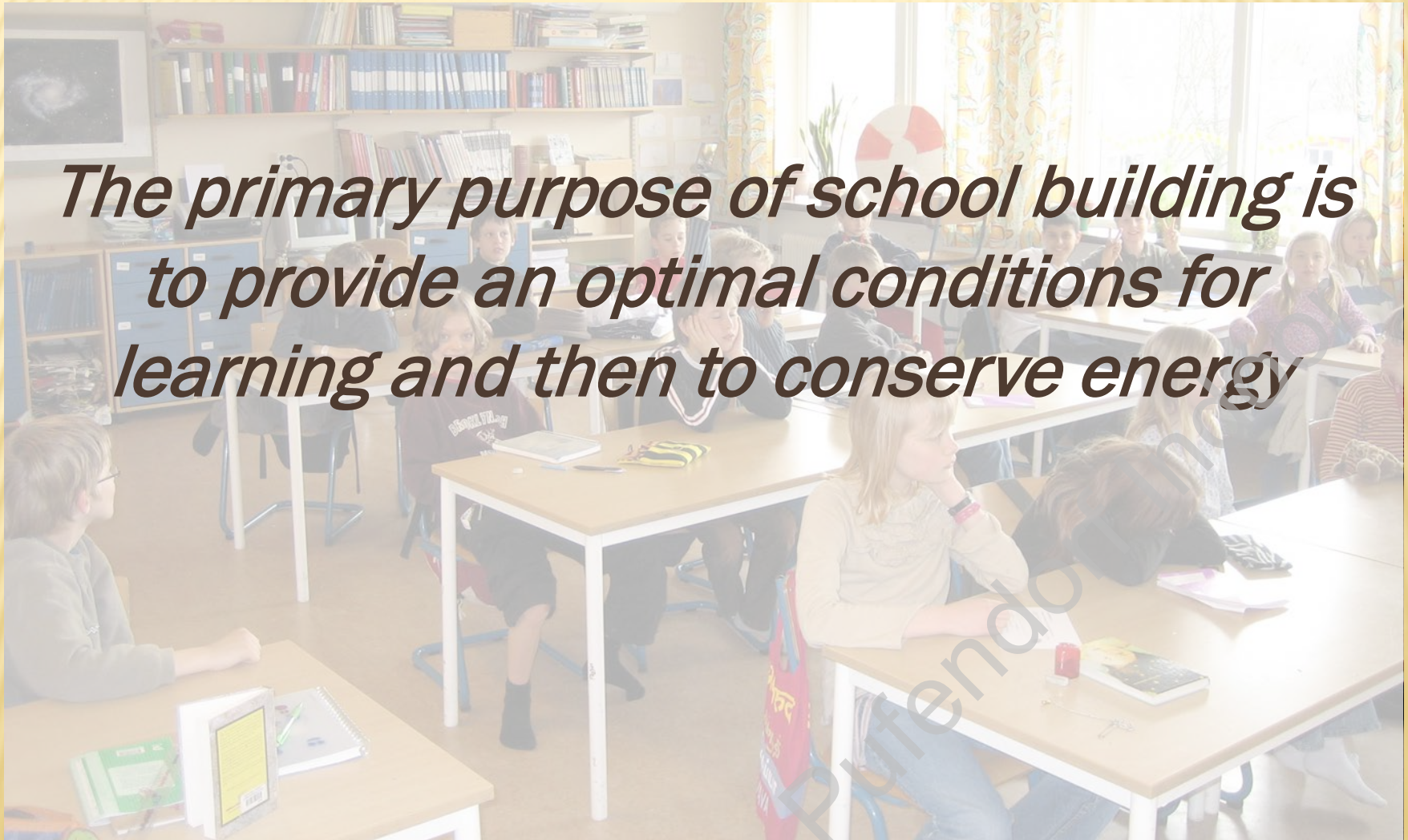


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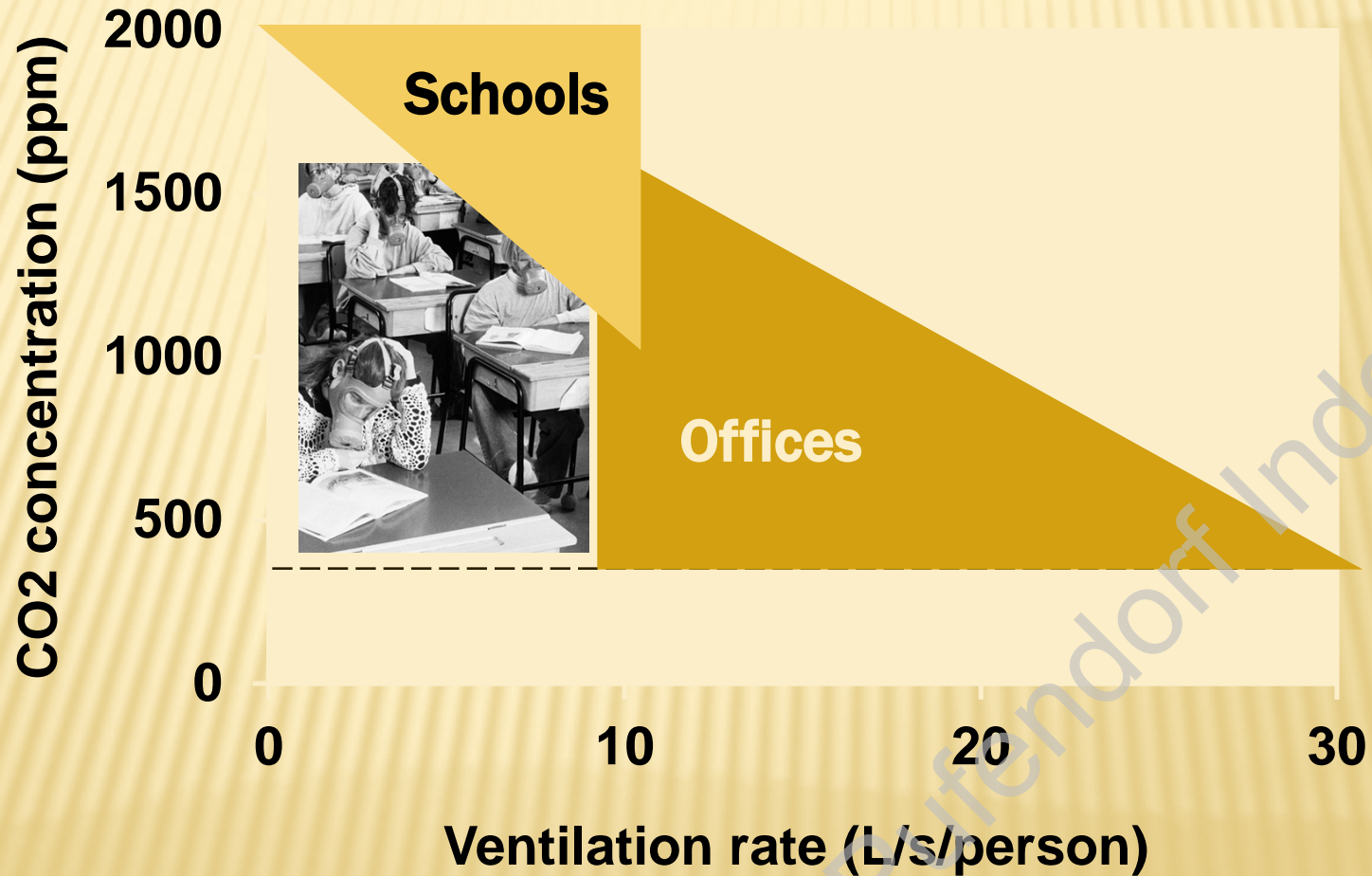


# PURPOSE OF THE SCHOOL

*The primary purpose of school building is to provide an optimal conditions for learning and then to conserve energy*

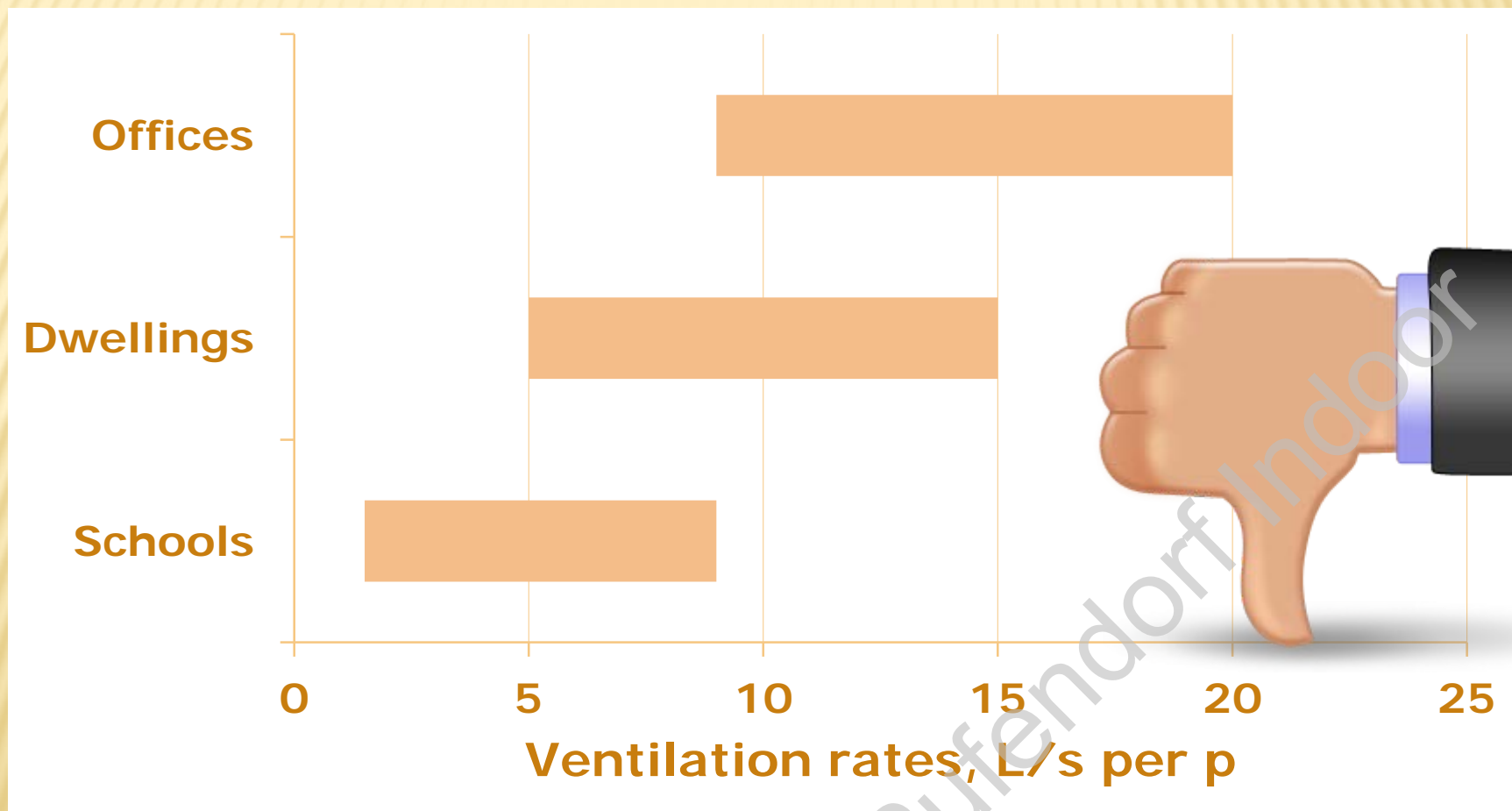


# VENTILATION REQUIREMENTS IN SCHOOLS



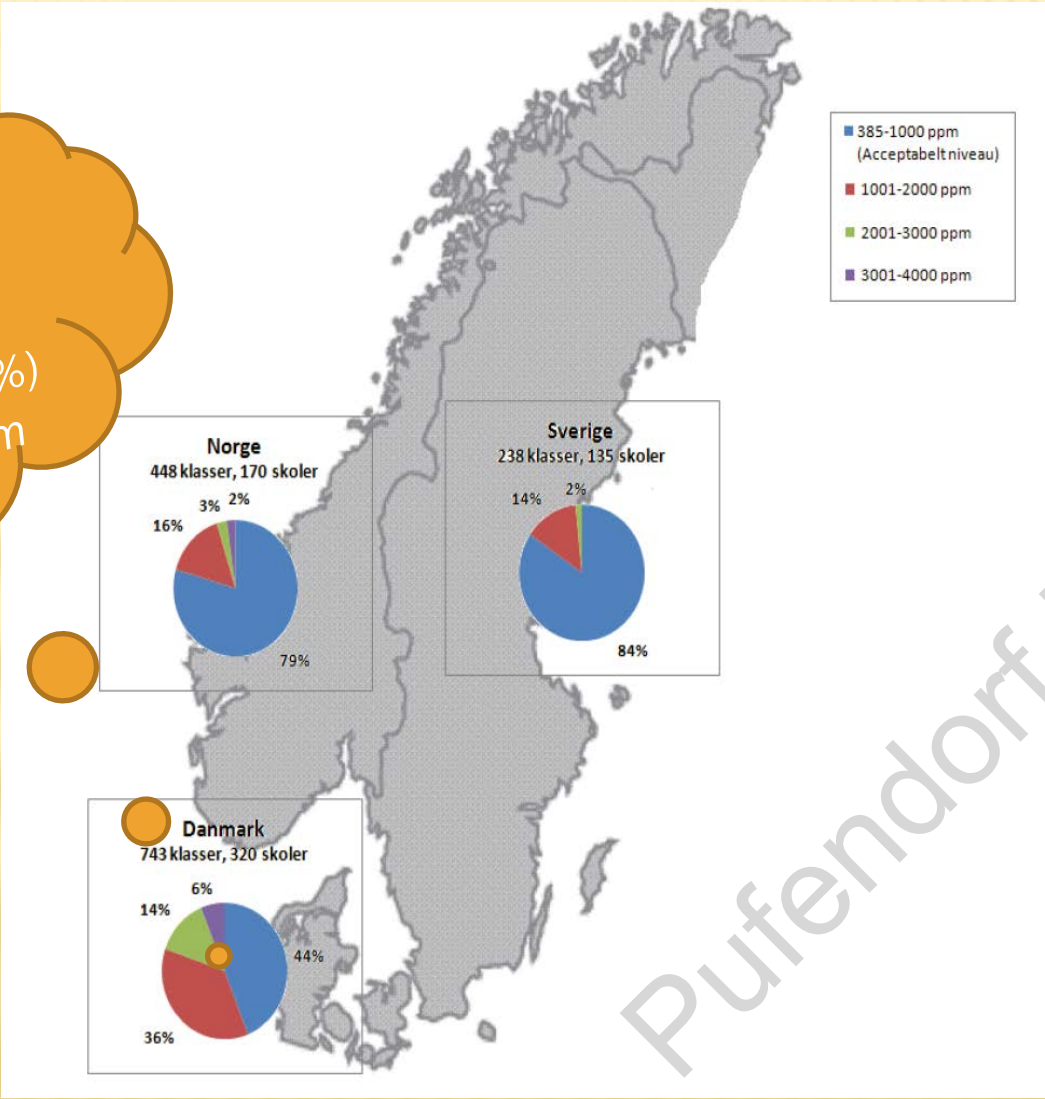


# MEASURED VENTILATION RATES IN EU BUILDINGS



# SCANDINAVIAN SCHOOLS

Mass Experiment  
2014: 59%  
(Sealand: 64%)  
>1,000 ppm



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**WHAT ARE CONSEQUENCES?**

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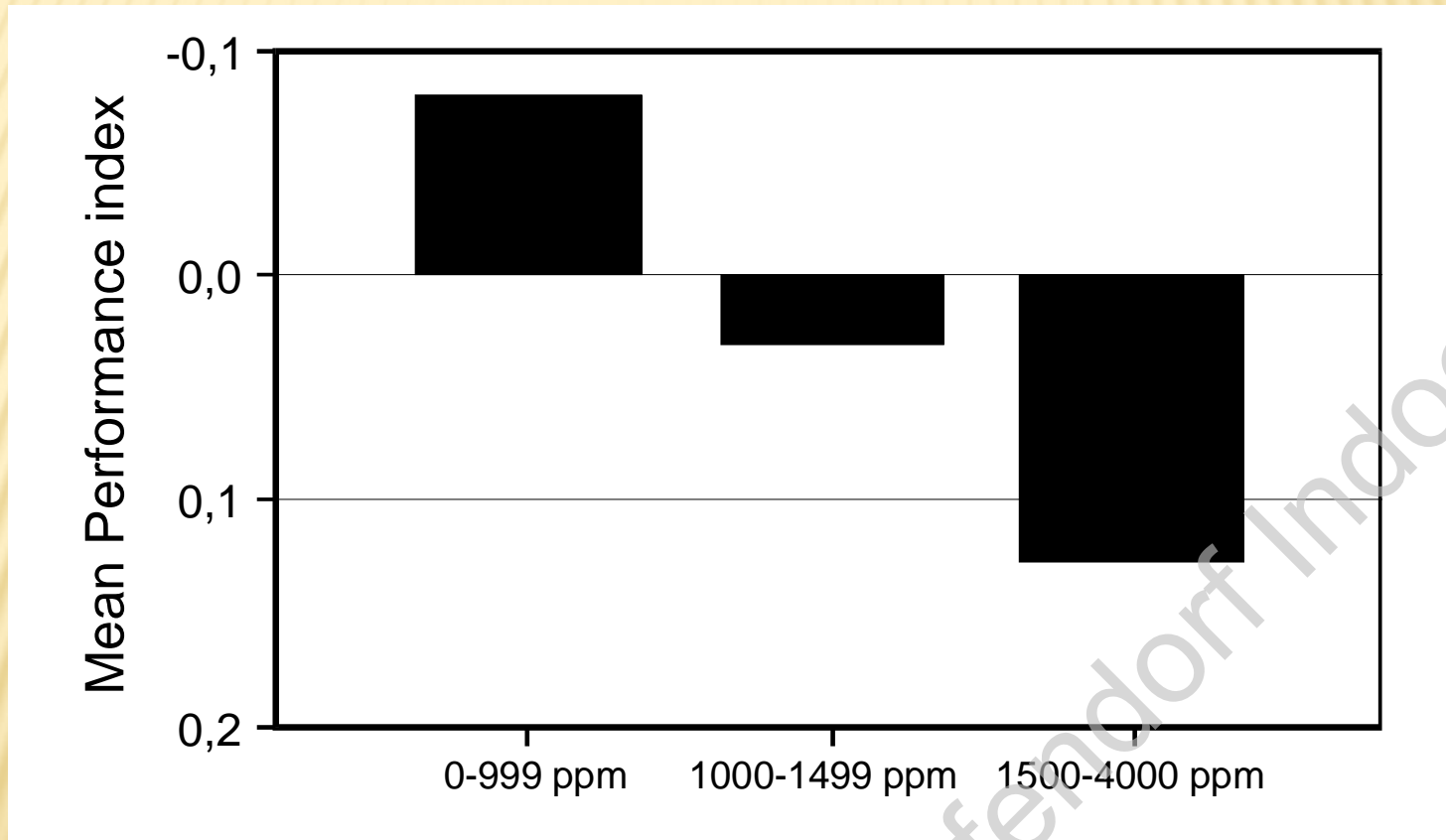
# SCHOOLWORK (CHILDREN AND TEACHERS)

- ✘ Attitudes: cognitive skills
- ✘ Academic behaviours: typical school tasks and absence rate
- ✘ Academic achievements: standardized tests
- ✘ Usually 3rd to 6th grades (9-12 years old)



# ATTITUDES: PSYCHOLOGICAL TESTS FOR MEASURING COGNITIVE SKILLS

(*simple/choice reaction time, colour-word vigilance*)



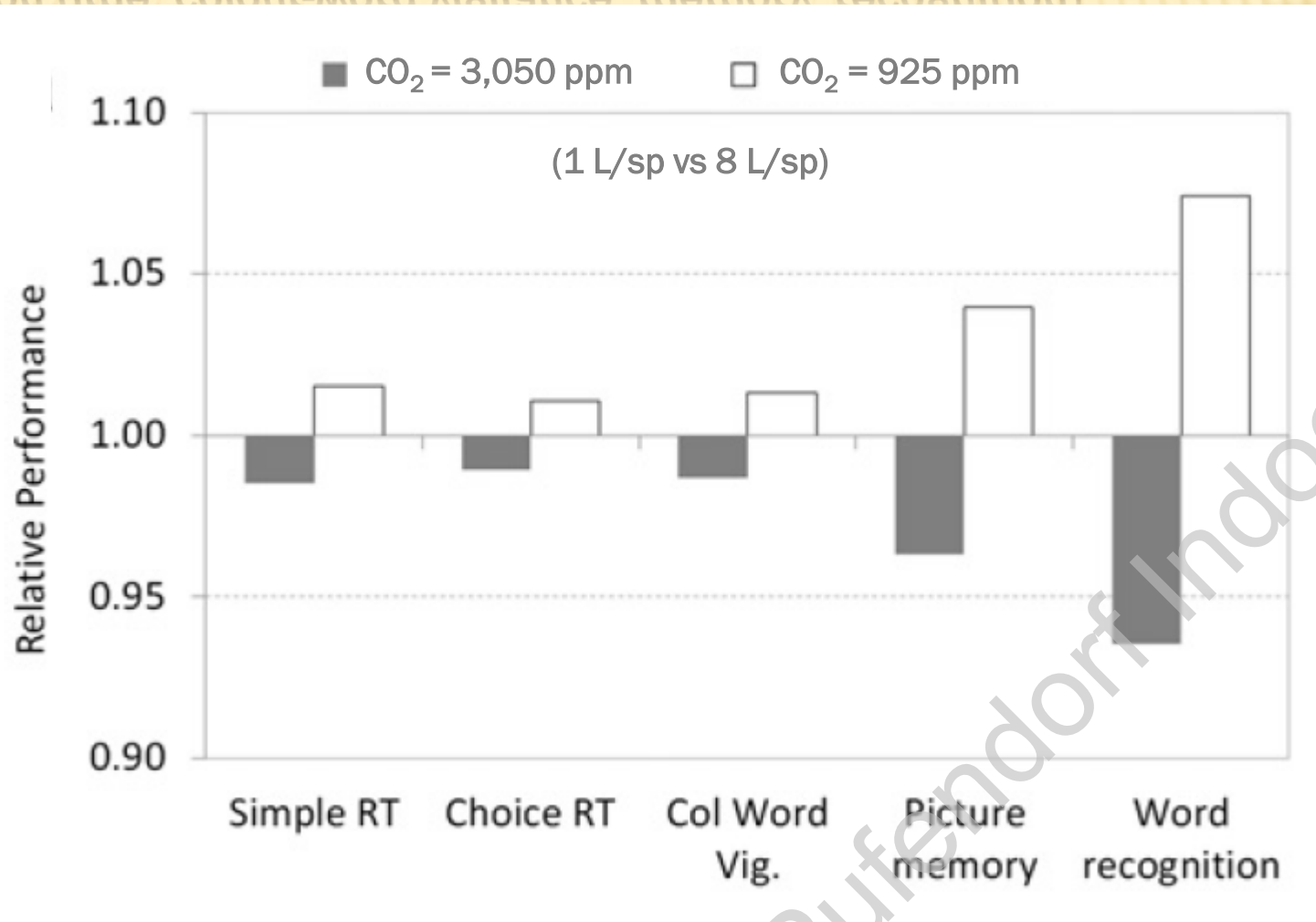
# ATTITUDES: PSYCHOLOGICAL TESTS FOR MEASURING COGNITIVE SKILLS

- ✘ 18 schoolchildren, age 10-11
- ✘ 4 test sessions with range of cognitive tasks at CO<sub>2</sub> of 690±122 (501-983 ) ppm and 2909±474 (2096-4140) ppm
- ✘ Significant effects (better at lower CO<sub>2</sub>): simple reaction time, power of attention and (close to significant) digit vigilance reaction time and choice reaction time
- ✘ Non significant effects: digit vigilance accuracy and false alarms, choice reaction time accuracy, picture recognition response and accuracy.
- ✘ Pupils significantly more calm at high CO<sub>2</sub> (self-assessed)



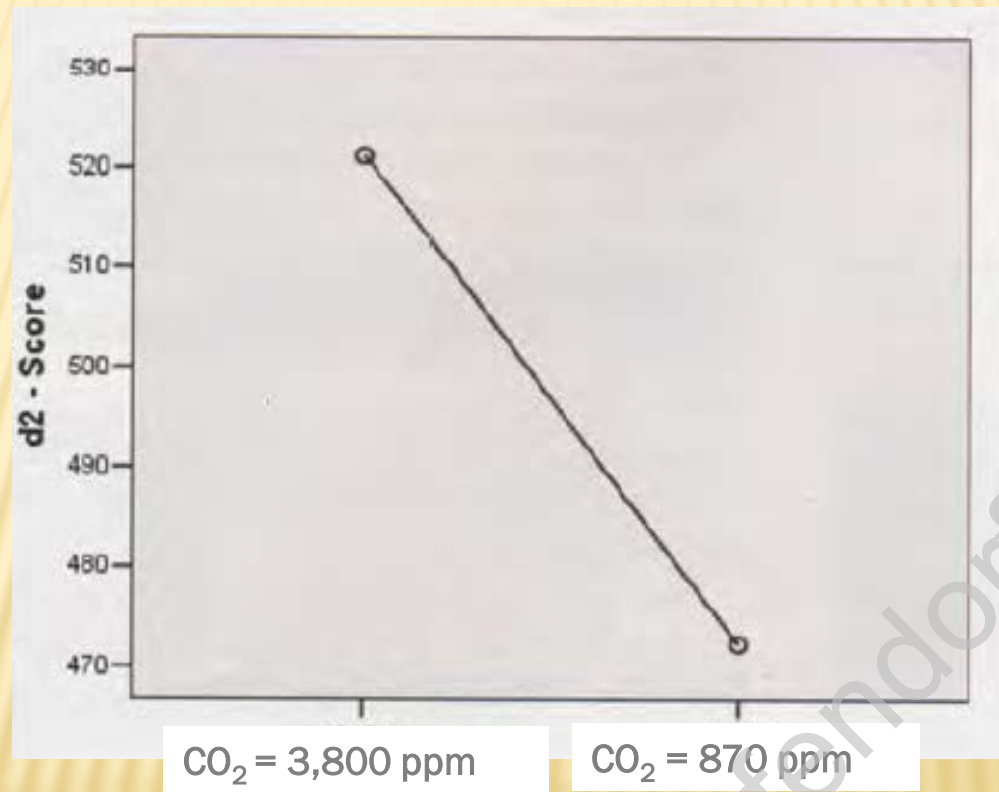
# ATTITUDES: PSYCHOLOGICAL TESTS FOR MEASURING COGNITIVE SKILLS -2

(reaction time, colour-word vigilance, memory, recognition)



# ATTITUDES: PSYCHOLOGICAL TESTS FOR MEASURING COGNITIVE SKILLS

(d2-test for concentration)



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# COGNITIVE SKILLS ARE AFFECTED BY POOR CLASSROOM AIR QUALITY

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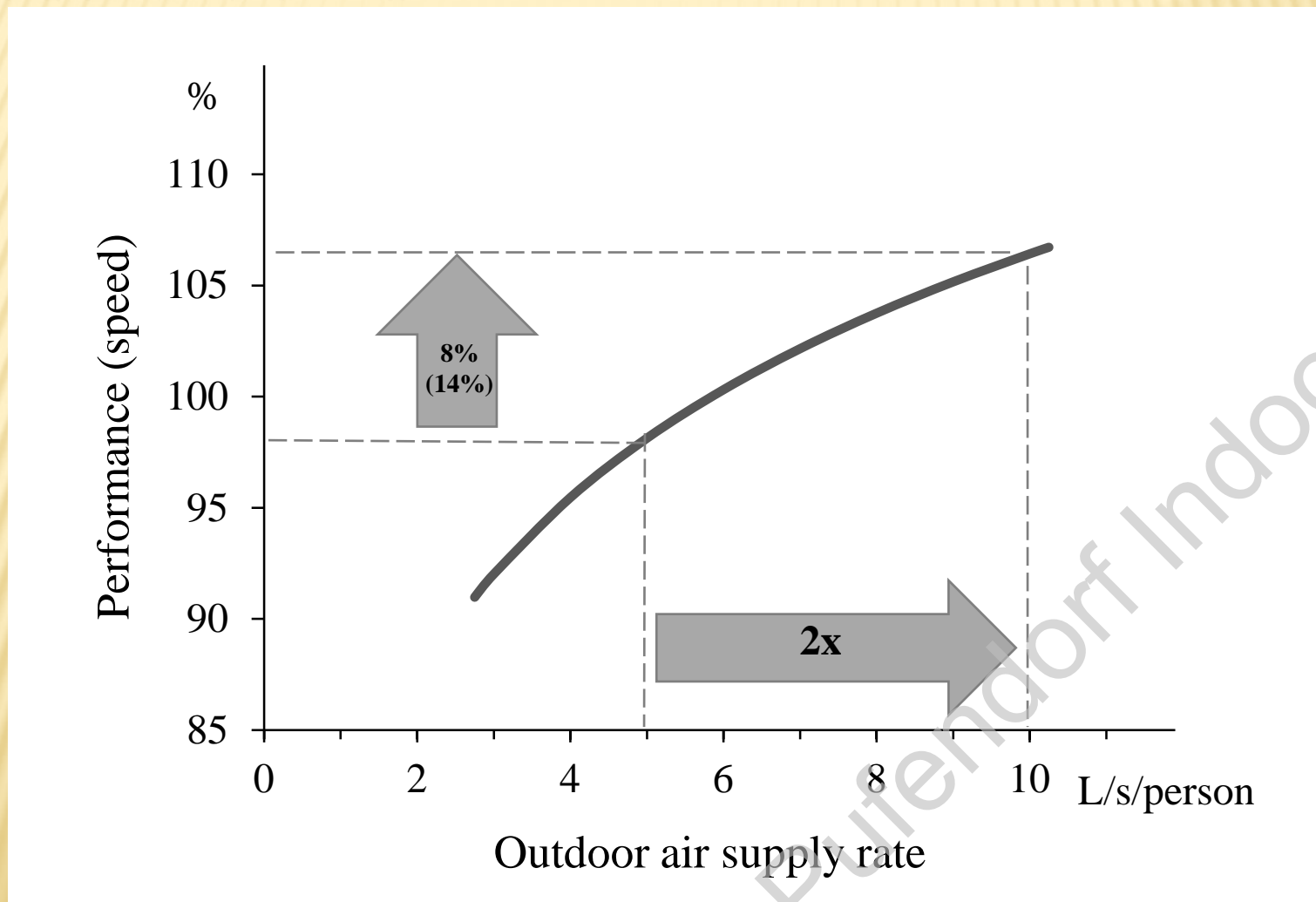
- ✘ Reaction time
- ✘ Memory
- ✘ Concentration
- ✘ Attention

*Important component skills securing proper education progress*

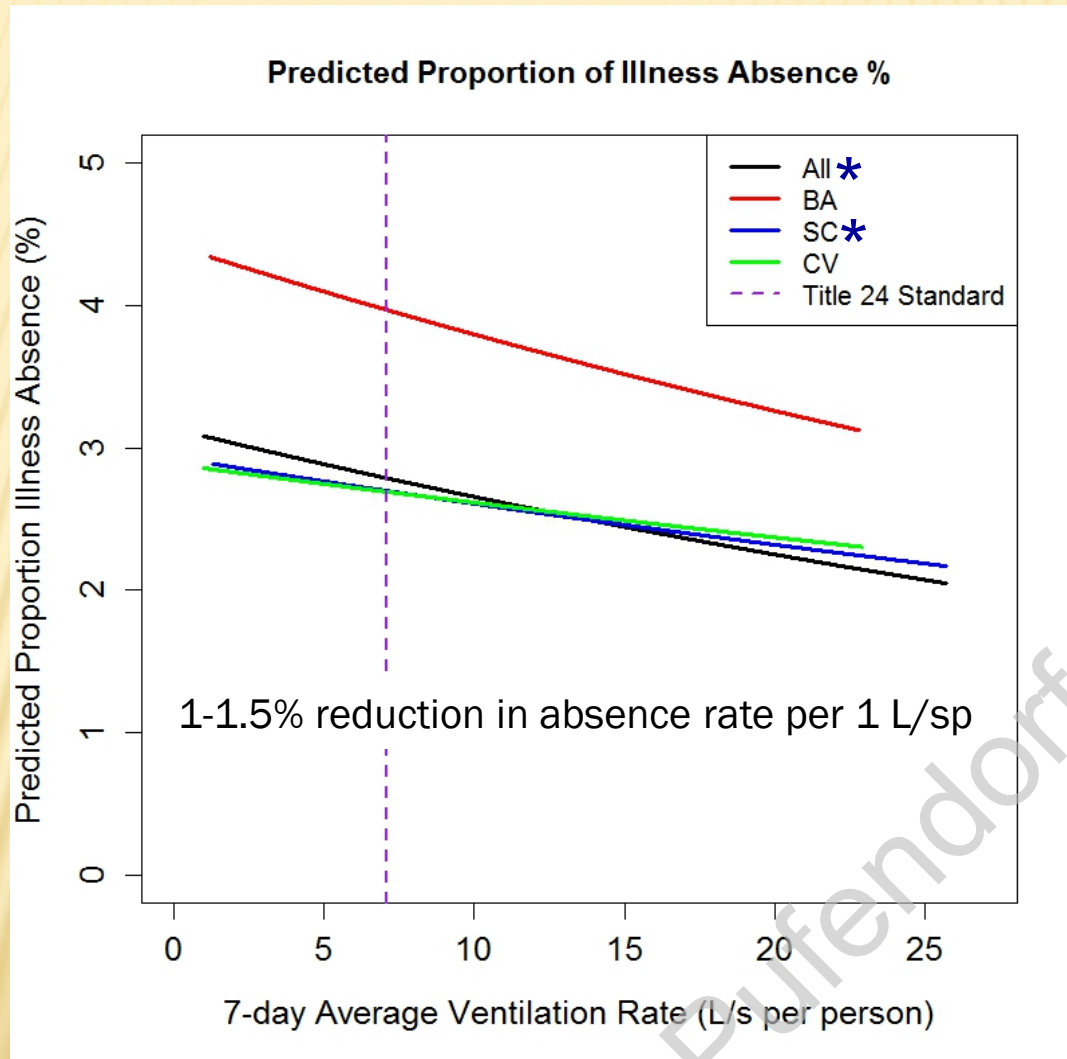
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# ACADEMIC BEHAVIOURS: EFFECTS FOR TYPICAL SCHOOL TASKS

(math & language based)



# ACADEMIC BEHAVIOURS: SCHOOL ATTENDANCE



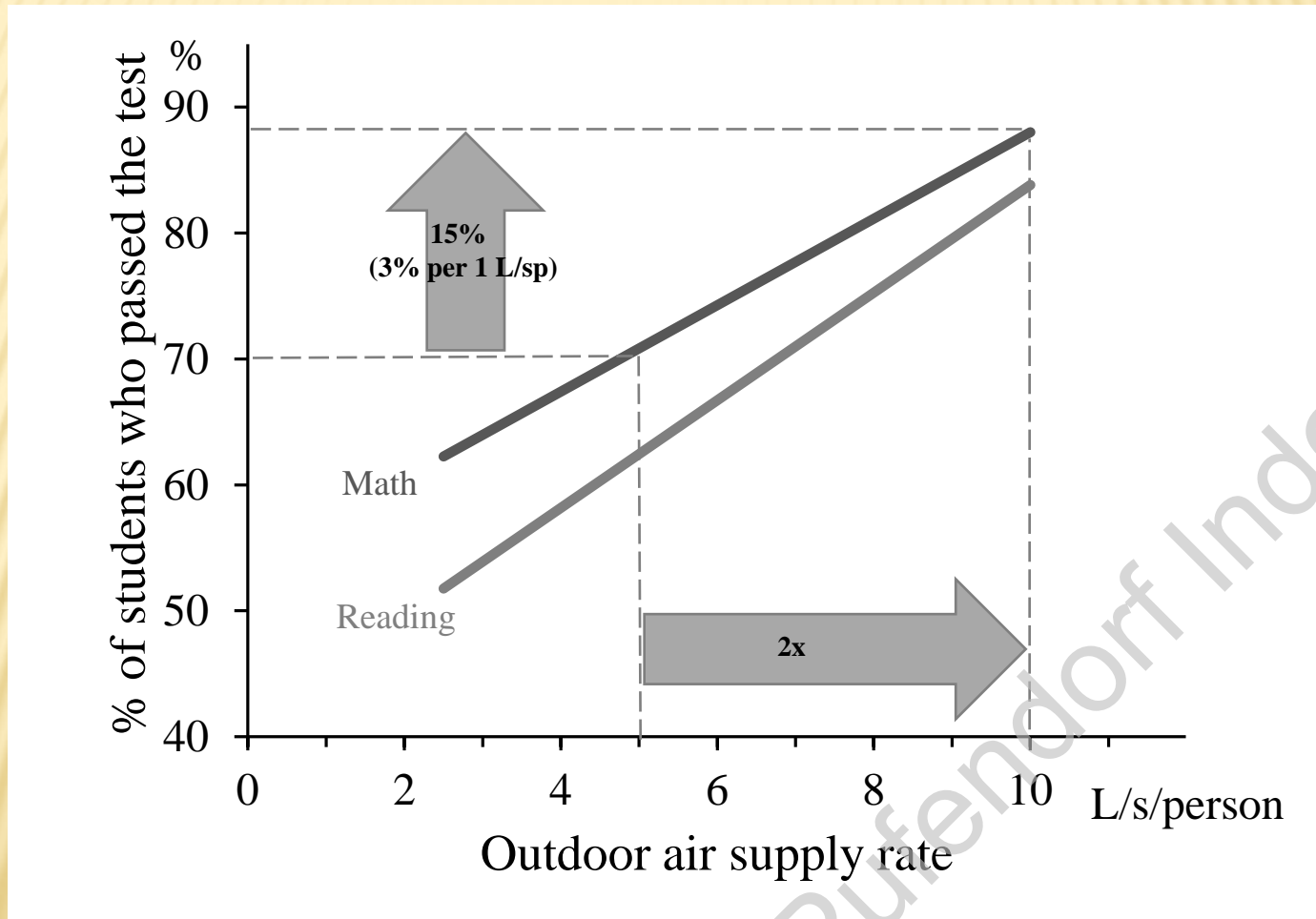


# CO<sub>2</sub>, SCHOOL ATTENDANCE, EDUCATIONAL ATTAINMENT

- ✗ 60 classrooms in 32 primary schools in Aberdeen
- ✗ Each school 2 classrooms (6-7 and 10-11 years old)
- ✗ 1 week measurements of CO<sub>2</sub> (temp rh) in early summer months: median 1086 ppm IQR 922-1310 ppm
- ✗ Absence rates for the whole school year
- ✗ Educational attainment (% of class attaining the average level expected for this group)
- ✗ Models adjusted for socioeconomic indicators (free school meals)
- ✗ **An increase of 100 ppm corresponded to 0.2% increase in absence rates** (0.04-0.4) corresponding roughly to ½ day a year (in 190 days school year); average absence rate in Scottish schools 5.1%
- ✗ No effects on attainment

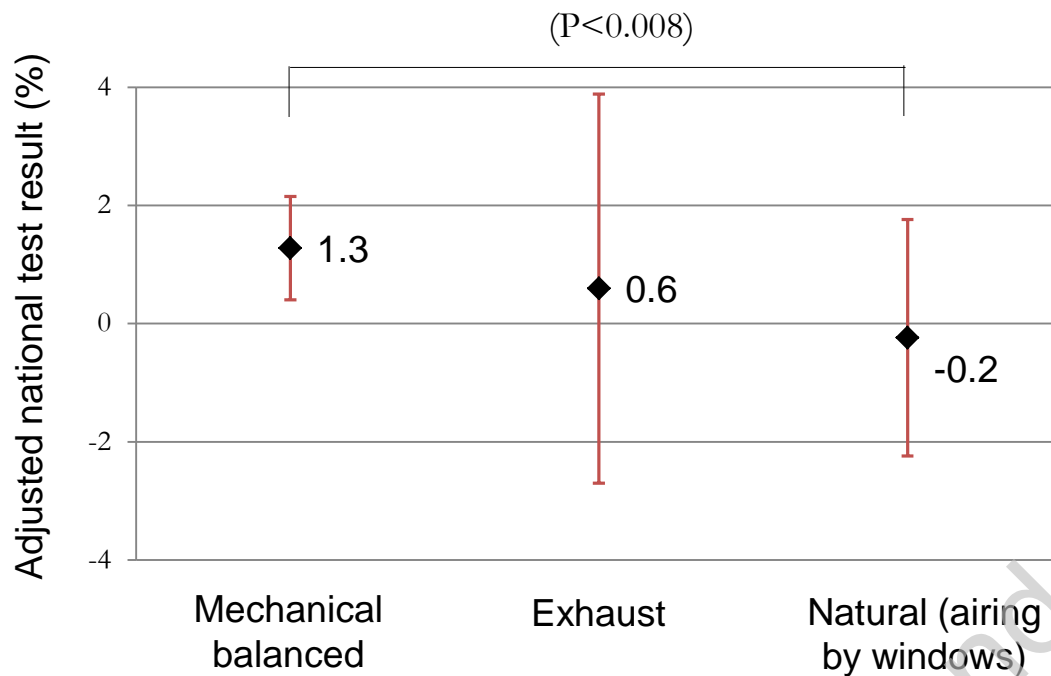
# ACADEMIC ACHIEVEMENTS: STANDARDIZED TESTS

(number of pupils who passed)



# NATIONAL STANDARD EDUCATIONAL TESTS


(math, language-based, science (chemistry/physics, geography, biology), foreign language )





# OECD: COUNTRIES WITH BETTER TEST SCHOOL RESULTS HAVE HIGHER GROWTH RATE

The OECD new survey of Adults Skills finds that foundation skills in mathematics have a major impact on individual's life chances. The survey shows that poor mathematics skills severely limit people's access to better-paying and more rewarding jobs; at the aggregate level, inequality in the distribution of mathematics skills across populations is closely related to how wealth is shared within nations. Beyond that, the survey shows that people with strong skills in mathematics are also more likely to volunteer, see themselves as actors rather than objects of political processes, and are even more likely to trust others.



1 L/s per pupil higher  
ventilation rate:

- \* About 3% higher performance of schoolwork
- \* About 1.5% lower absence rates

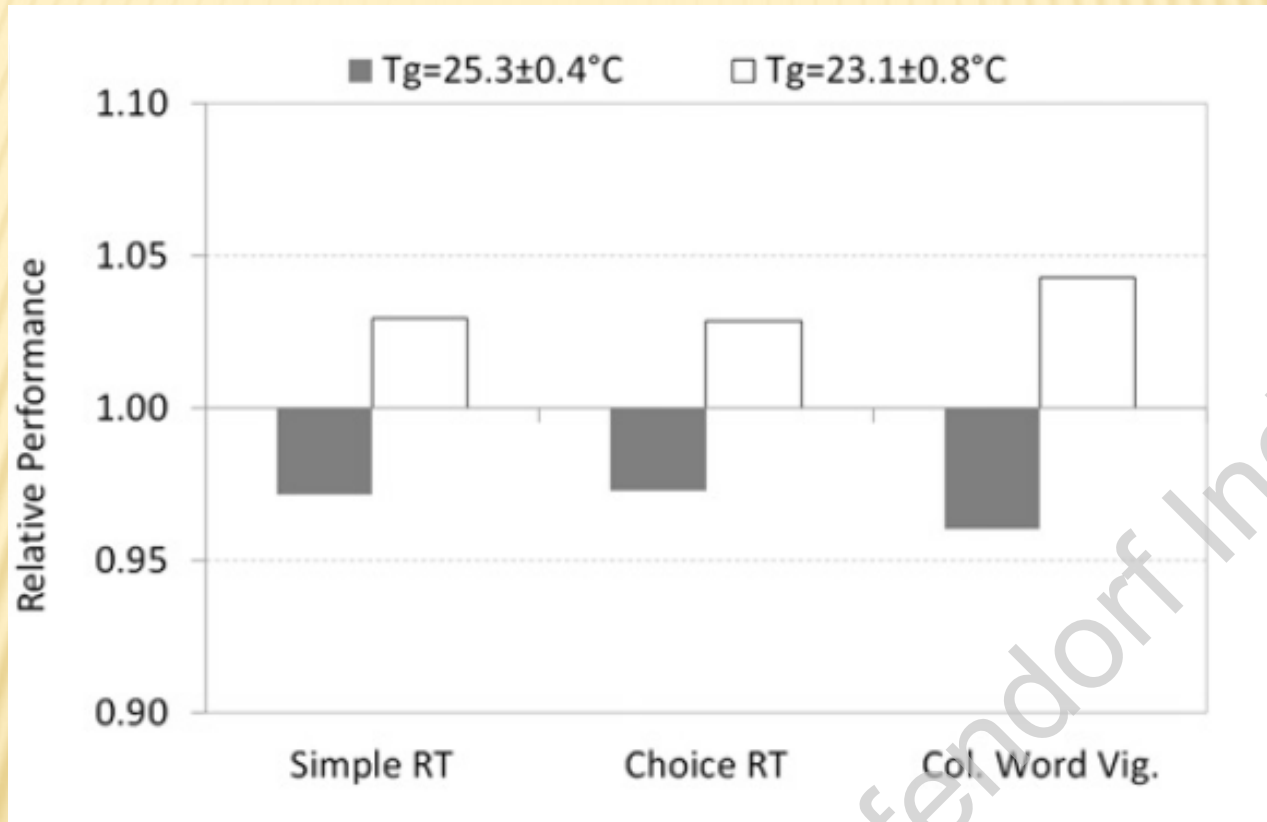
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**HOW ABOUT OTHER INDOOR CLIMATE  
PARAMETERS?**

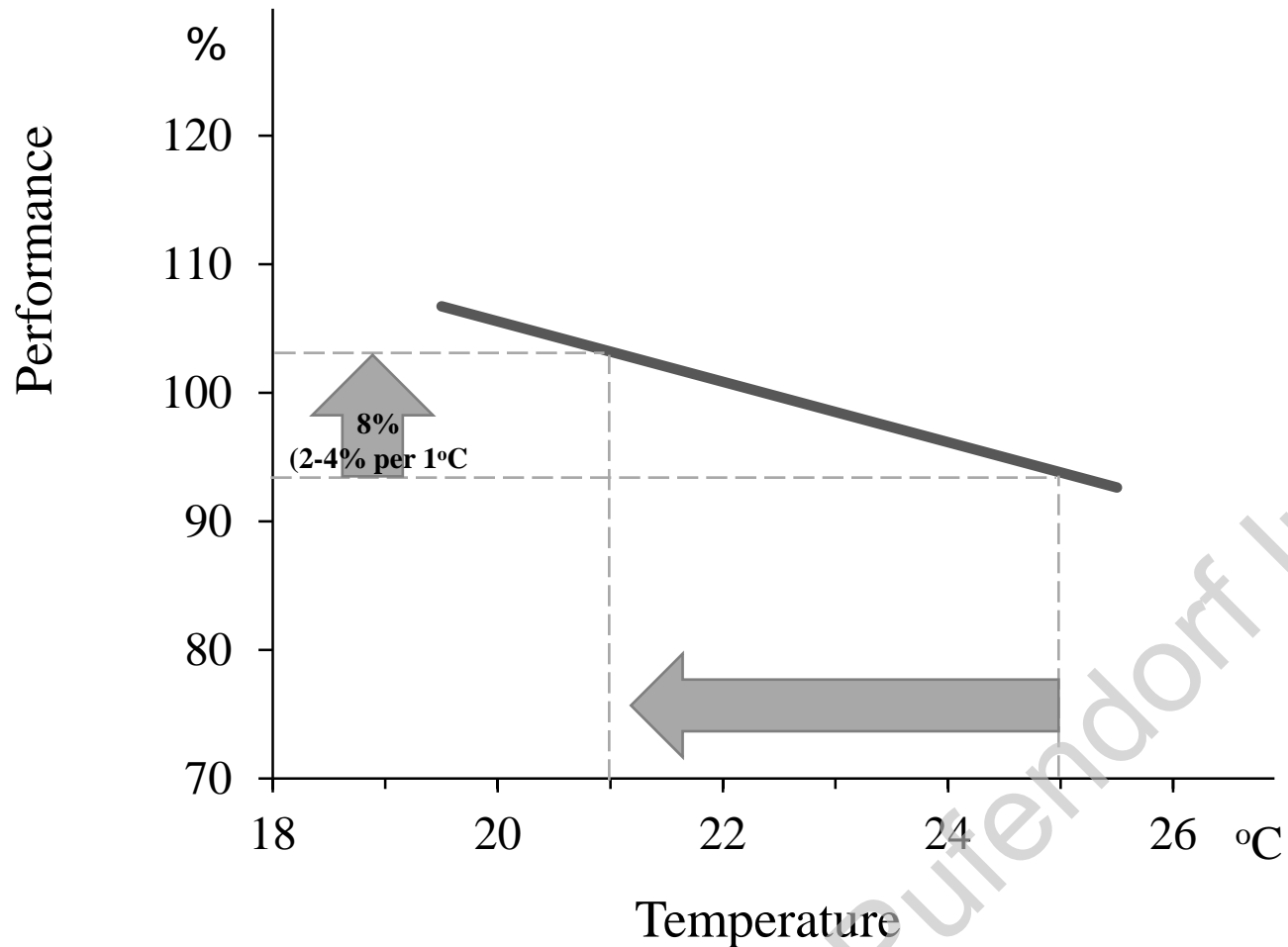
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# CLASSROOM TEMPERATURE, PSYCHOLOGICAL TESTS



# CLASSROOM TEMPERATURE, TYPICAL SCHOOL TASKS

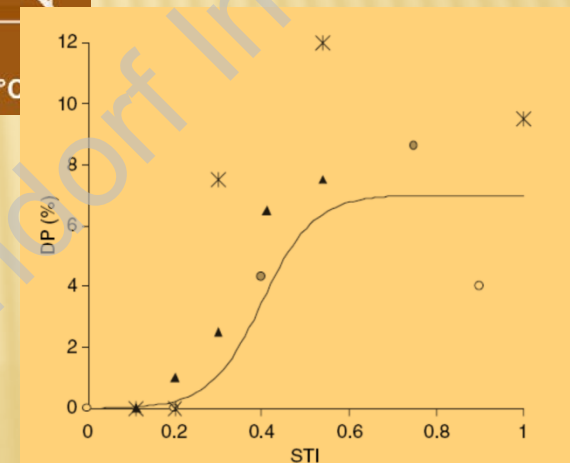
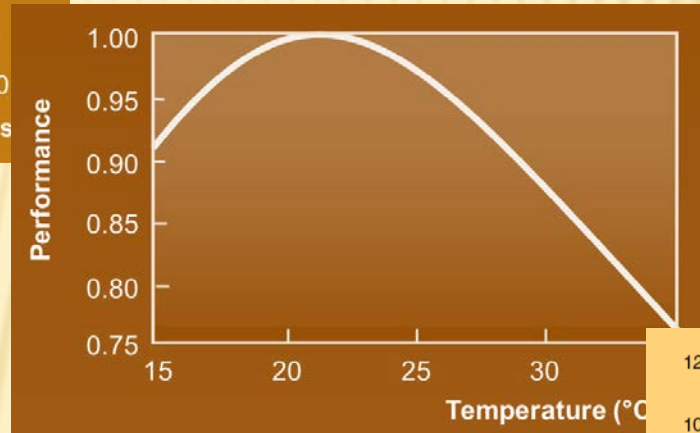
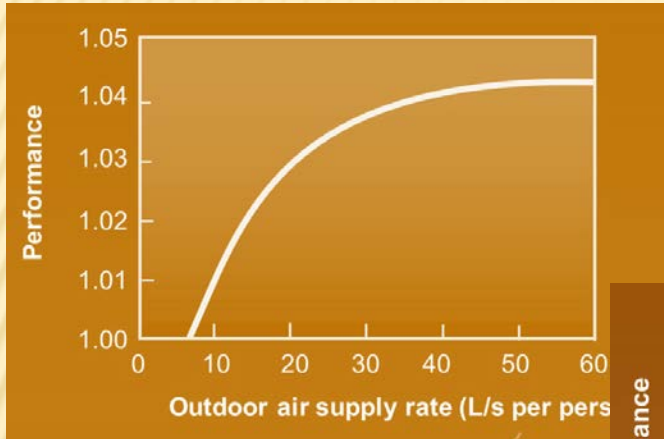


**HOW ABOUT TEACHERS?**

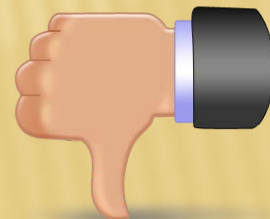
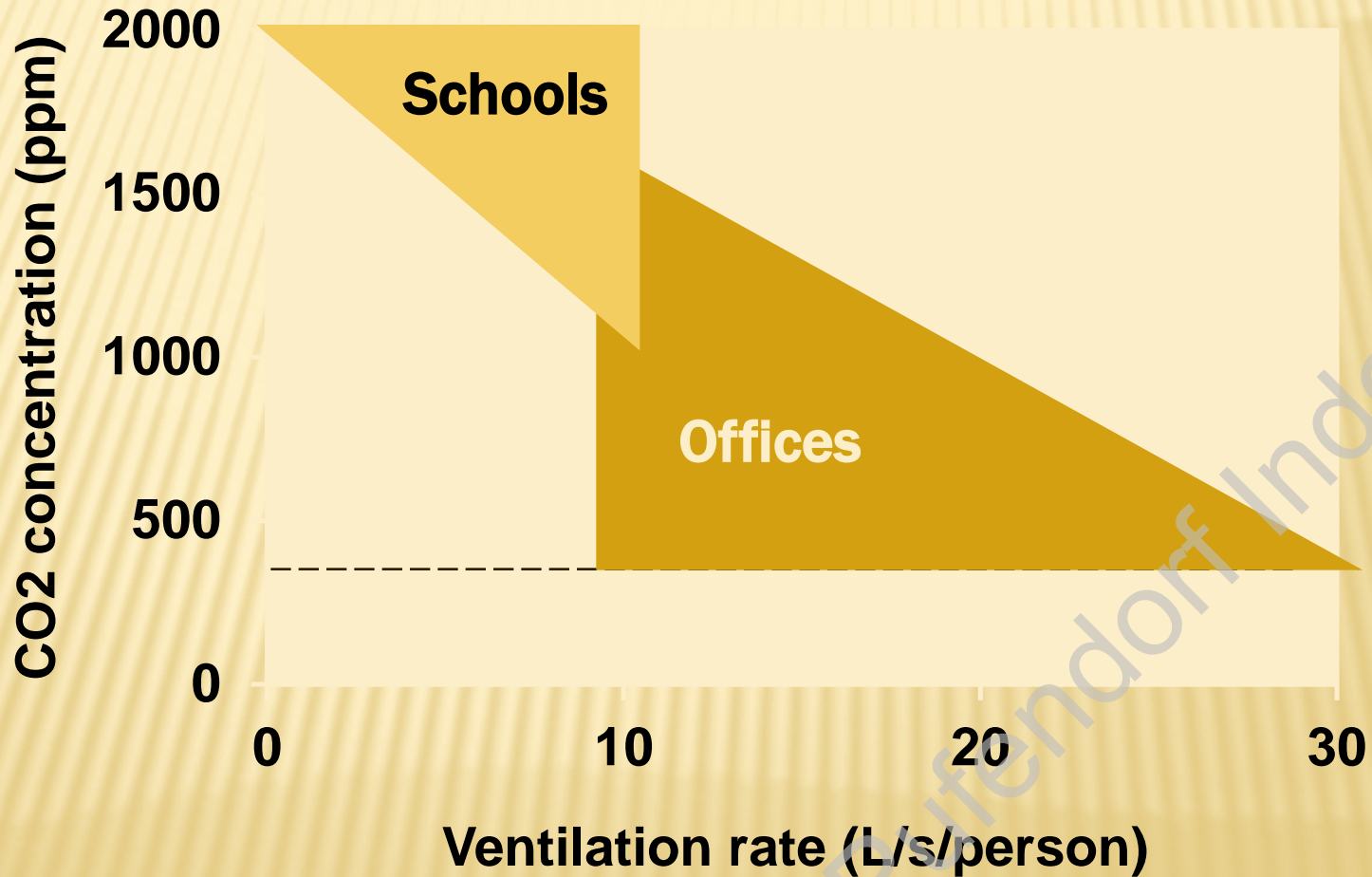
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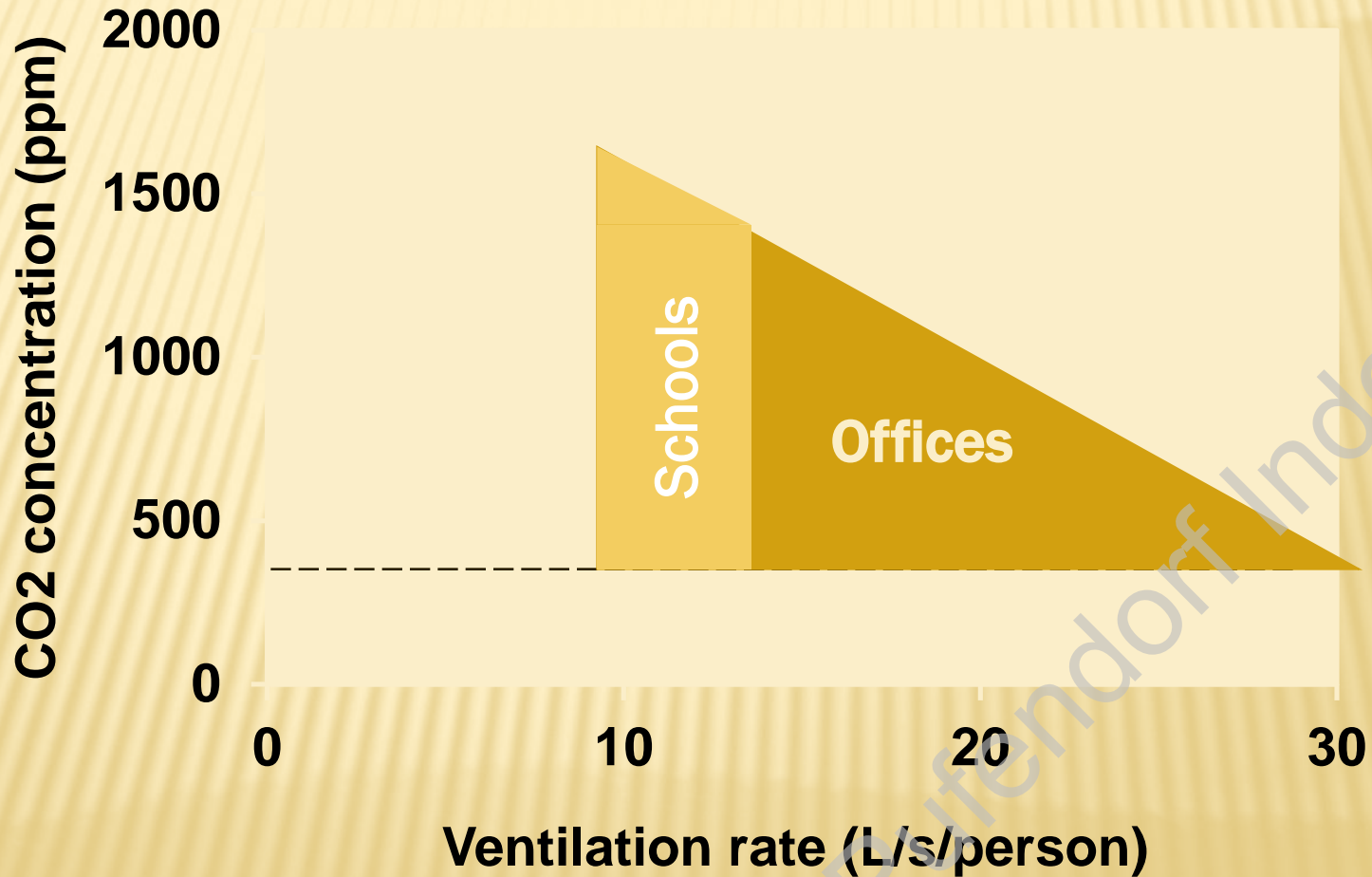
# TEACHERS ALSO PERFORM LESS WELL



# VENTILATION REQUIREMENTS IN SCHOOLS

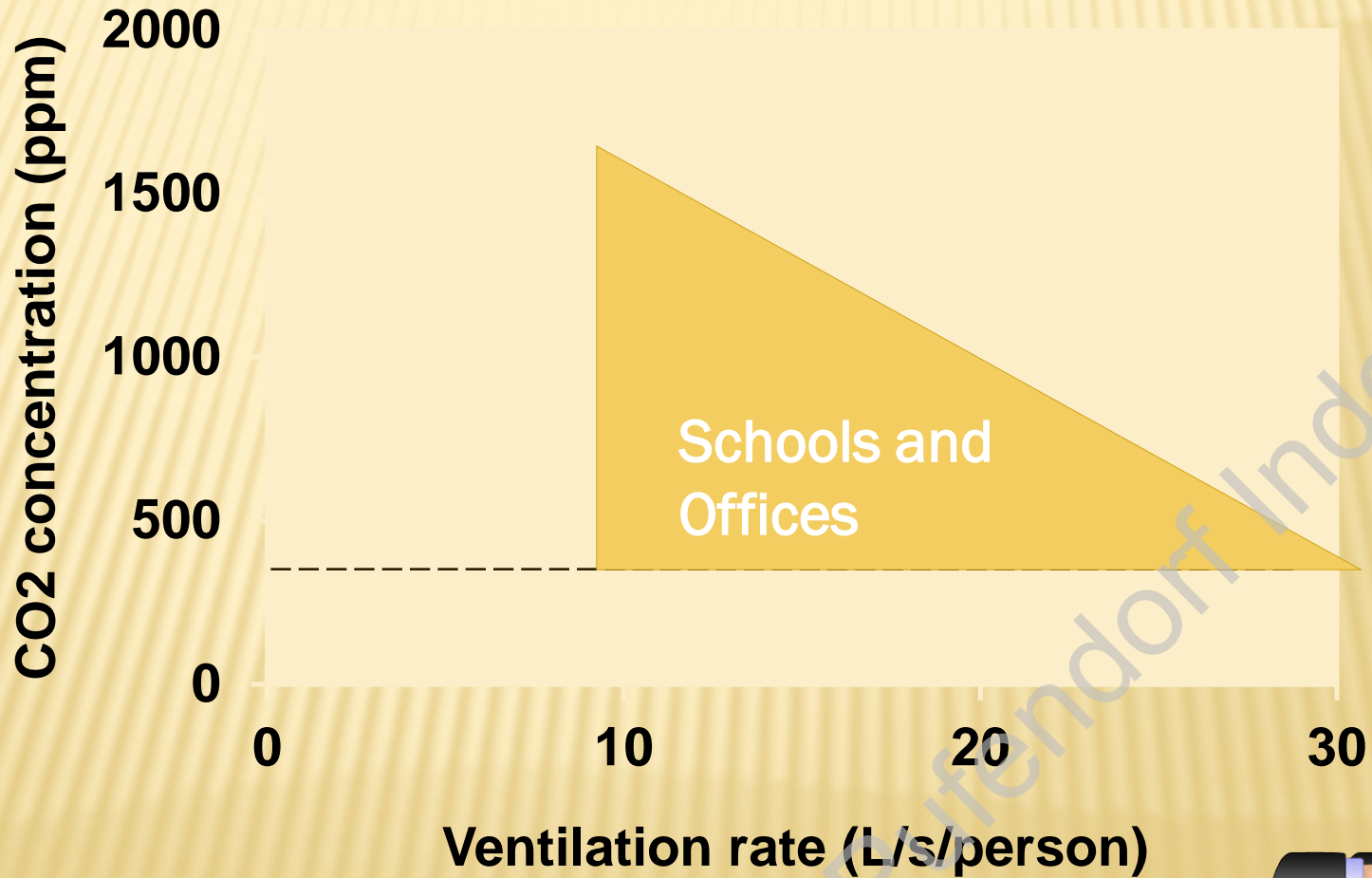


# VENTILATION REQUIREMENTS IN SCHOOLS





# VENTILATION REQUIREMENTS IN SCHOOLS



*“It is certain that the additional expenses per pupil of the best ventilation needed not exceed the price of one or two cheap lunches.”*

*New Hampshire School District  
Ventilation Code,  
1893*

**WHAT IS THE COST?**



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# CONSEQUENCES

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- ✘ 15% reduced performance ( $1/8$ ) => 1 school year
- ✘ More time for teaching to reach the same educational targets, teacher cost => compare with the renovation costs
- ✘ Absence rates of pupils (& care takers) and teachers => cost of absenteeism
- ✘ Loss of opportunity (salary) as regards future work => socio-economic impact
- ✘ Consequences for national economy => GDP and public expenses/incomes



# SOCIO-ECONOMIC CONSEQUENCES

AVERAGE EARNINGS, AGE 26-28 (includes those not working)

\$16,000

15,500

OECD 2010: countries with better test school results have higher growth rate

14,000

13,500

30

40

50

60

70

KINDERGARTEN CLASSMATES' TEST SCORE PERCENTILE

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# SUMMARY REMARKS

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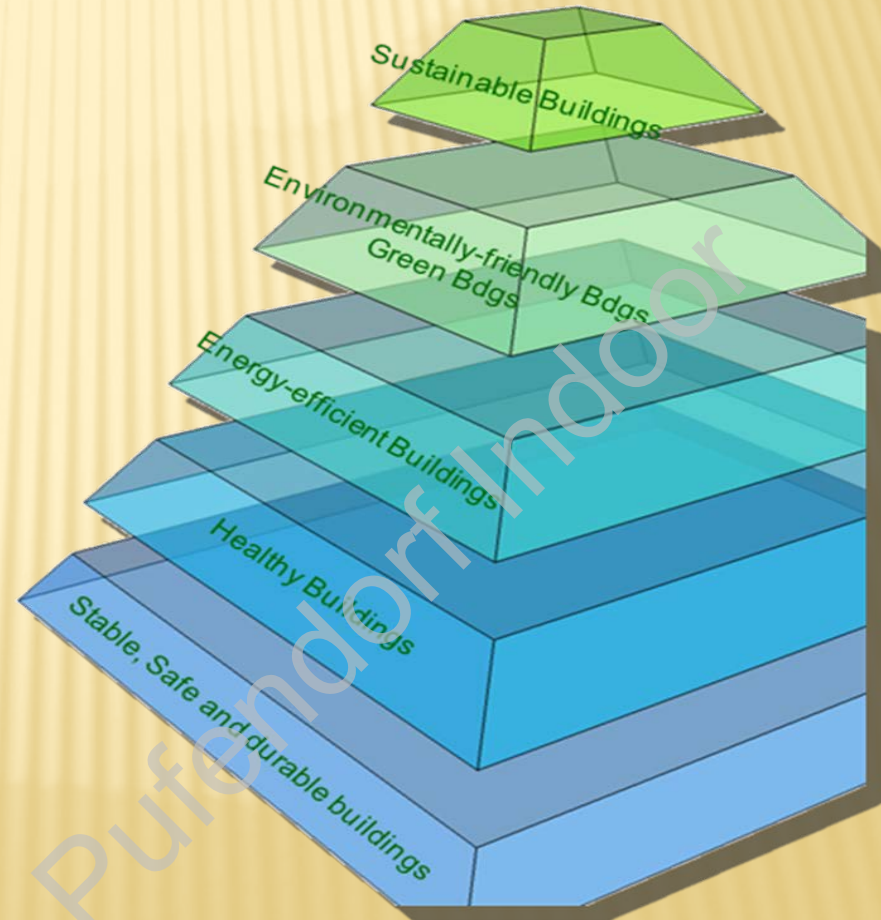
# ENERGY IS A LOW HANGING FRUIT





# PURPOSE OF THE SCHOOL

- ✘ Buildings are not constructed to save energy
- ✘ They must first promote health together with energy and sustainability, health is included in the sustainability concept
- ✘ The primary purpose of school building is to provide an optimal conditions for learning and then to conserve energy
- ✘ IEQ in classrooms plays an important role in learning process, probably as important as teaching materials and methods
- ✘ High IEQ should become an urgent educational priority



# QUESTIONS?

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