

Green Schools: Attributes for Health and Learning

Committee to Review and Assess the
Health & Productivity Benefits of Green Schools

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High Performance Green Schools

Collaborative for High Performance Schools CHPS

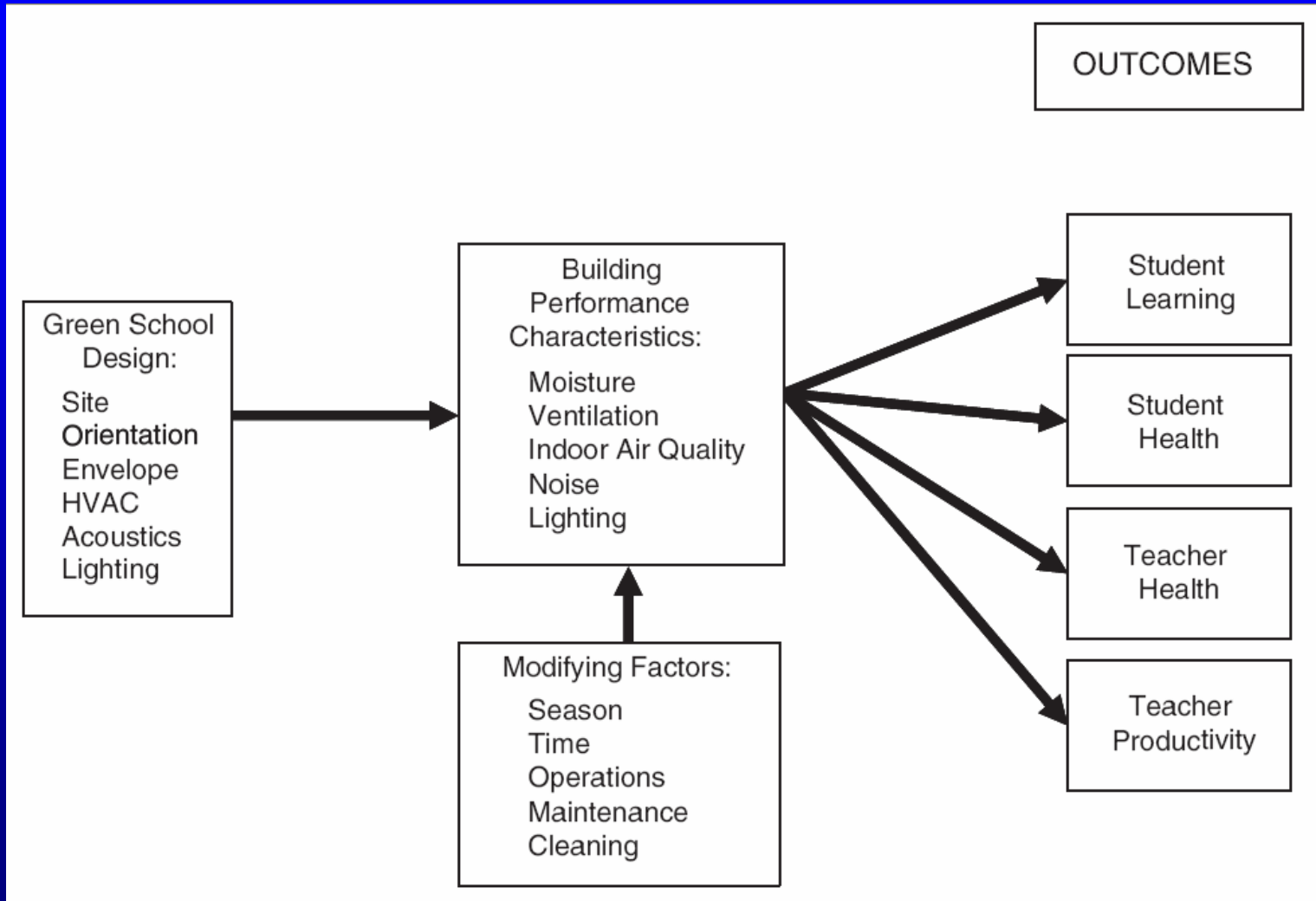
LEED for Schools

High Performance Green Schools are energy, material and resource efficient facilities designed, constructed and maintained to optimize the health, productivity and learning potential of everyone who experiences them.

Sustainable Sites
Water Efficiency
Energy and Atmosphere
Materials and Resources
Environmental Quality



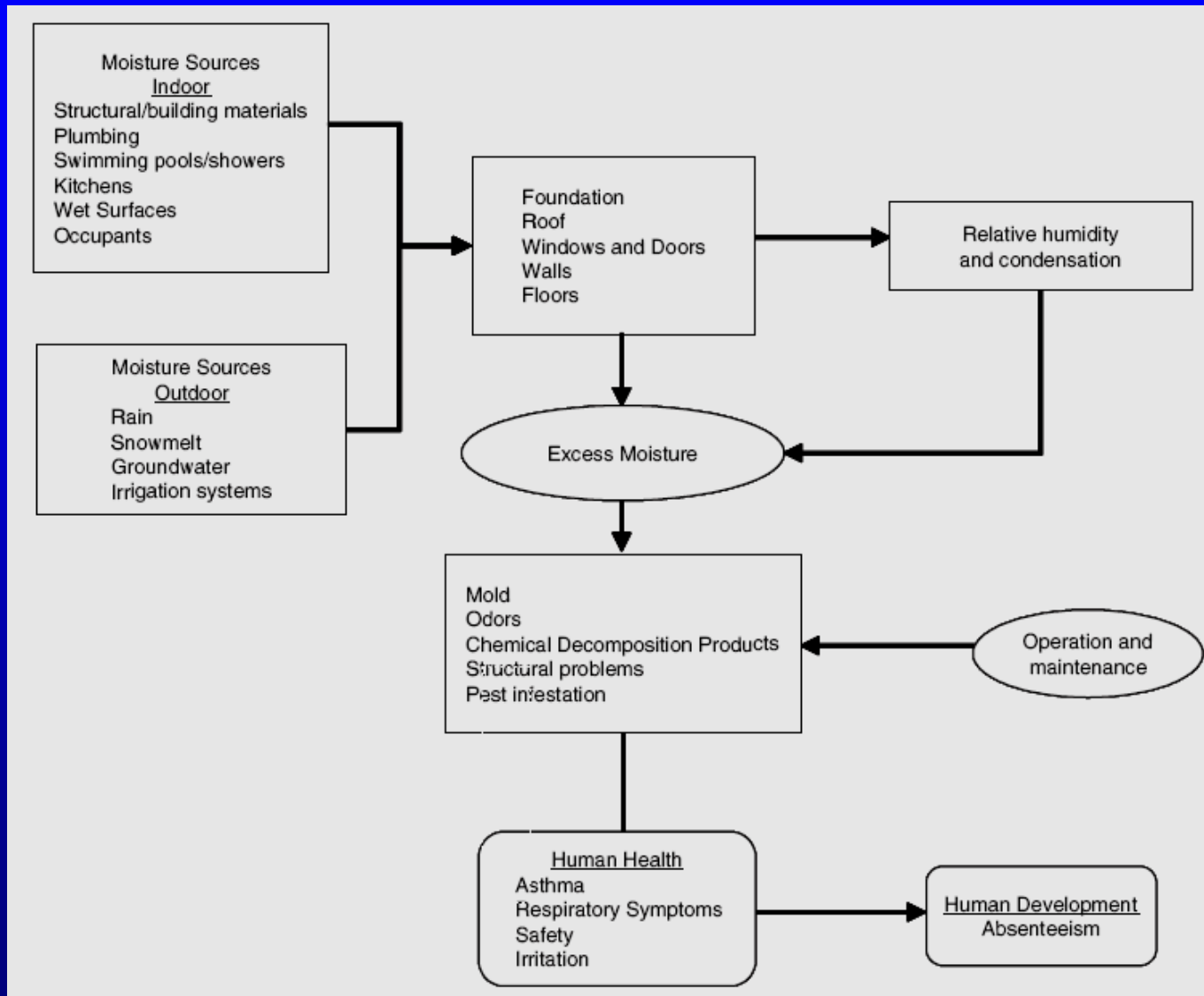
Conceptual model for evaluating links between green school buildings and outcomes for learning, health and productivity



Complexity of the Task

- Establishing cause-and-effect relationships between an attribute of a green school and its effect on people is very difficult.
- The committee did not identify any well-designed, evidence-based studies concerning the *overall* effects of green schools, or that analyze whether green schools are actually different from conventional schools in regard to the outcomes of interest.
- Scientific research related to the effects of green schools will be difficult to conduct until the physical characteristics that differentiate green from conventional schools are clearly identified.
- The attributes of a green school that may potentially affect health, learning, and productivity differently than those in conventional schools should be clearly specified.

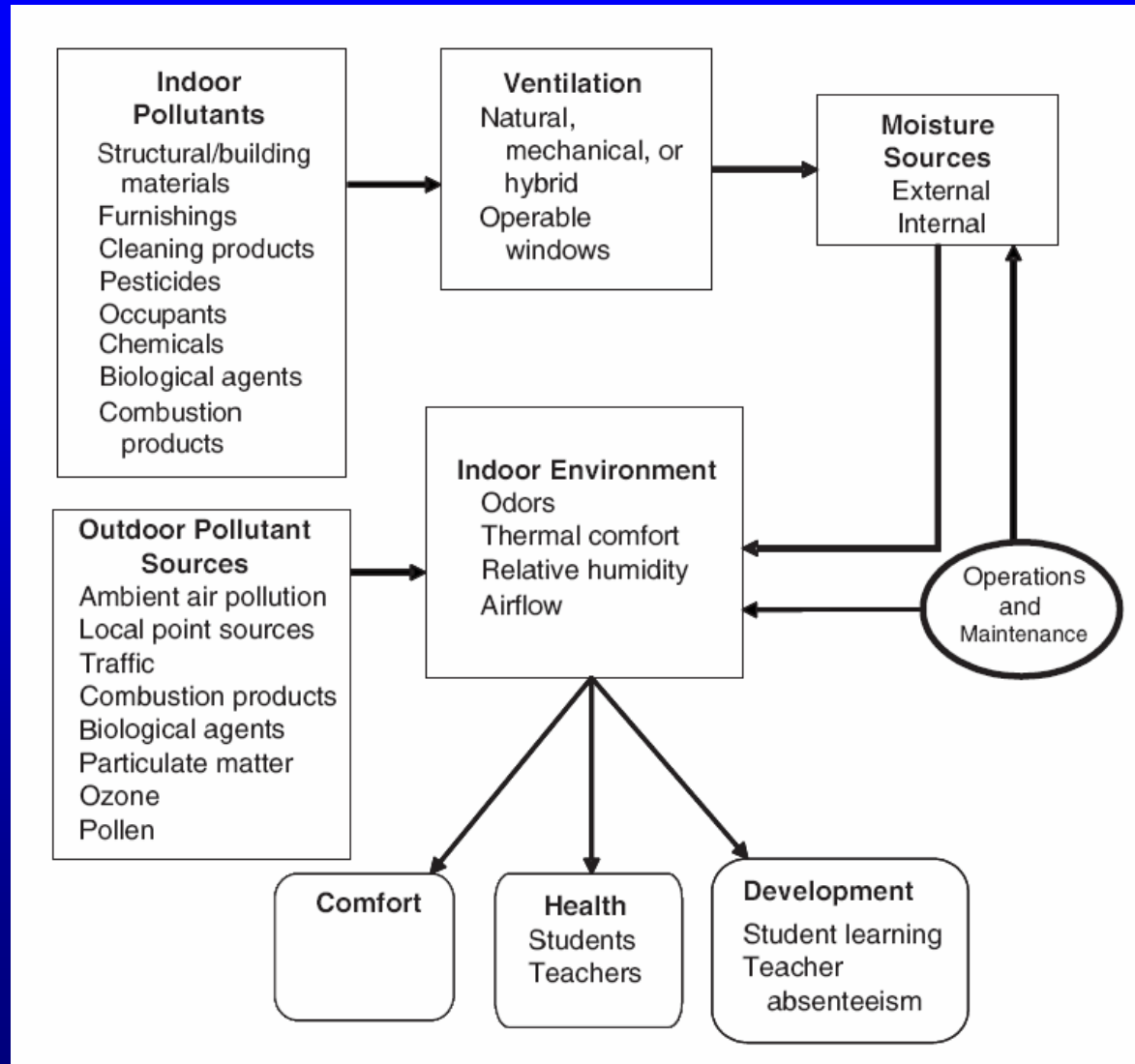
Building Envelope, Moisture Management, and Health



Building Envelope, Moisture Management, and Health

- There is sufficient scientific evidence to establish an association between excess moisture, dampness, and mold in buildings and adverse health outcomes.
- Excess moisture in buildings may result in increased maintenance and repair costs.
- Well-designed, -constructed, and –maintained building envelopes are critical to the control and prevention of excess moisture and molds.
- Current green school guidelines do not adequately address the design detailing, construction, and long-term maintenance to ensure that a building is kept dry during its service life.
- Future green school guidelines should emphasize the control of excess moisture, dampness, and mold to protect the health of children and adults and to protect a building's structural integrity.
- Research should be conducted on the moisture resistance and durability of materials used in school construction.

Indoor Air Quality, Health, and Performance



Indoor Air Quality, Health, and Performance

- A robust body of scientific evidence indicates that the health of children and adults can be affected by indoor air quality.
- Key factors in providing good IAQ are: ventilation rate and effectiveness; filter efficiency; temperature, humidity, and moisture control; O&M and cleaning practices.
- Indoor air pollutants and allergens from mold, pet dander, cockroaches, and rodents contribute to respiratory and asthma symptoms among children and adults.
- Reduction of pollutant loads through increased ventilation and effective filtration has been shown to reduce the occurrence of building related symptoms and to improve the health and comfort of occupants.
- There is evidence that many schools do not meet current ASHRAE standards. Research indicates that increasing the ventilation rate to exceed the standard will further improve comfort and productivity.

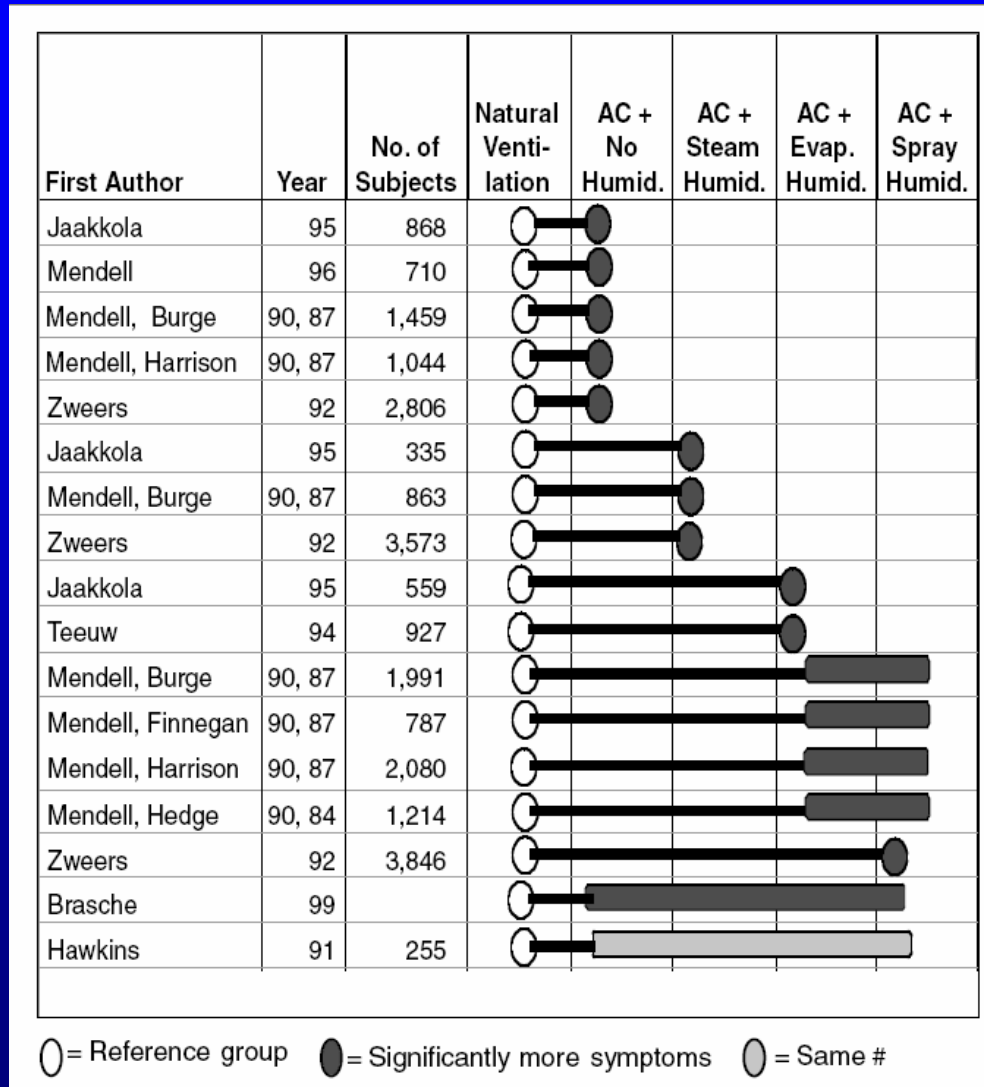
Indoor Air Quality, Health, and Performance

- Evidence indicates that increased ventilation rates can reduce the incidence of building-related symptoms, reduce pollutant loads associated with asthma, and improve the productivity of adult workers.
- Research comparing the effects of natural versus mechanical ventilation on human health is inconclusive. There is evidence that improper design and O&M of mechanical ventilation systems contribute to adverse health effects.
- Studies in office buildings indicate that productivity declines if room temperatures are too high; few studies have investigated the impact of room temperature in the school environment.
- No systematic research has examined the relationship of cleaning effectiveness to student and teacher health, student learning, or teacher productivity.

Indoor Air Quality, Health, and Performance

- Future green school guidelines should ensure that ventilation rates in schools meet current ASHRAE standards (at a minimum).
- Future green school guidelines should emphasize the importance of appropriate operation and preventive maintenance practices for ventilation systems.
- Additional research should be conducted to document the full range of costs and benefits of ventilation rates that exceed the current ASHRAE standard, and to determine optimum temperature ranges for school buildings.
- Studies should be conducted to examine the relationships of exposures from building materials, cleaning products and cleaning effectiveness to student and teacher outcomes.

Studies comparing the health effects of buildings with and without air conditioning systems

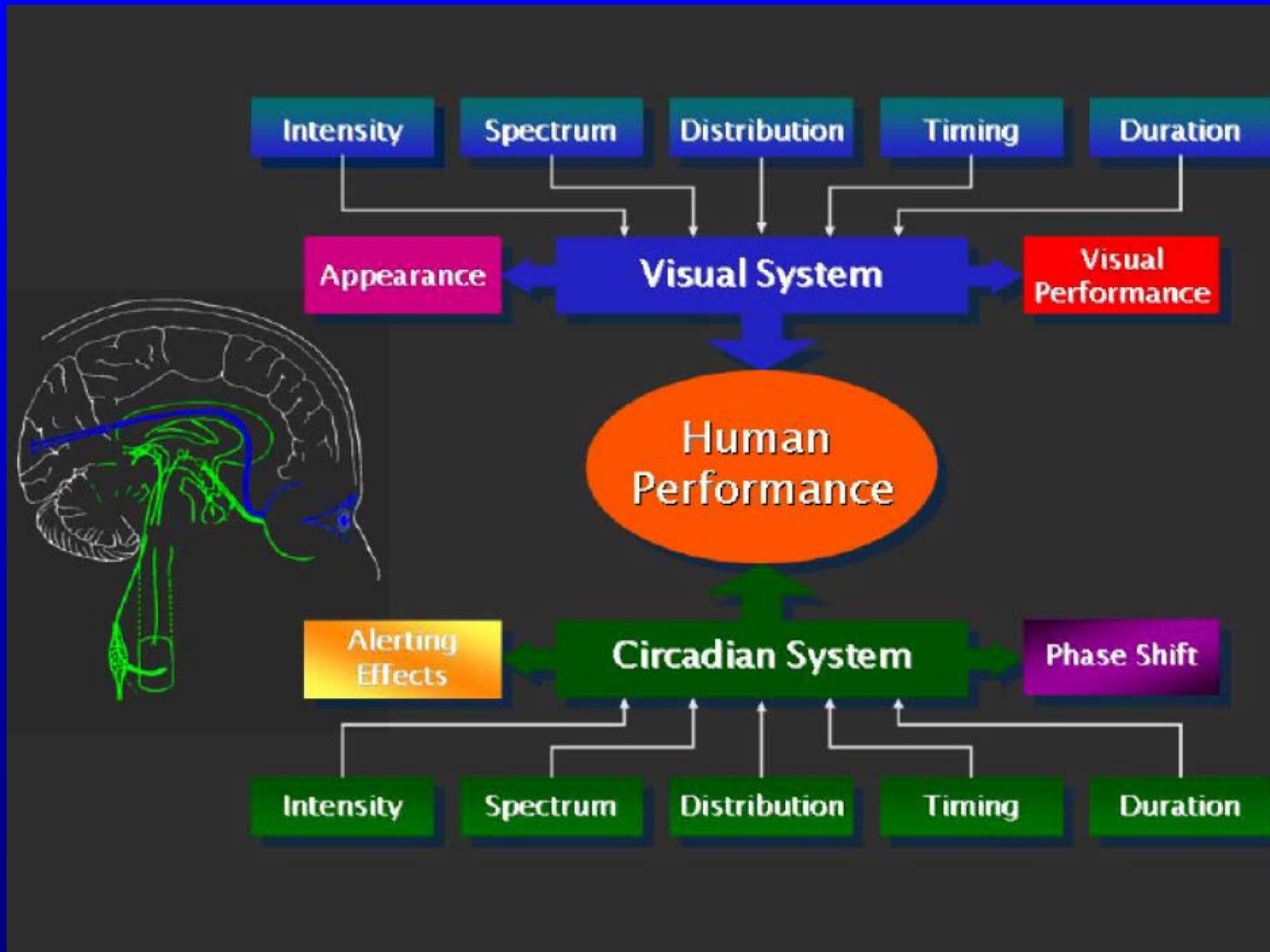


Source:
Seppanen and Fisk 2002

Lighting and Human Performance

- Research findings from studies of adult populations indicate that the visual conditions in schools resulting from both electric lighting and natural light should be adequate for most children and adults.
- It could be hypothesized that daylight might benefit children without properly corrected eyesight; however, this has not been systematically studied.
- Current green school guidelines typically focus on energy efficiency. Guidance for lighting design that supports visual performance is not provided.
- Currently, there is insufficient scientific evidence to determine whether an association exists between daylight and student achievement.
- A growing body of evidence suggests that lighting may play an important non-visual role in human health via the circadian system.

Light as it affects human performance and health through the visual and circadian systems: mechanisms critical



Lighting and Human Performance

- Future green school guidelines should seek to support the visual performance of students and teachers by encouraging lighting system design based on task, room configuration, and surface finishes.
- Future green school guidelines for the design and application of electric lighting systems should conform to the latest published engineering practices.
- Green school guidelines that encourage the extensive use of daylight should address electric control systems and specify easily-operated glare controls.
- Because light is important in regulating daily biological cycles, both acute effects on learning and lifelong effects on children's health should be researched.

Major debate about portfolio studies and confounding variables, the ability to control variables; and the value of intervention studies



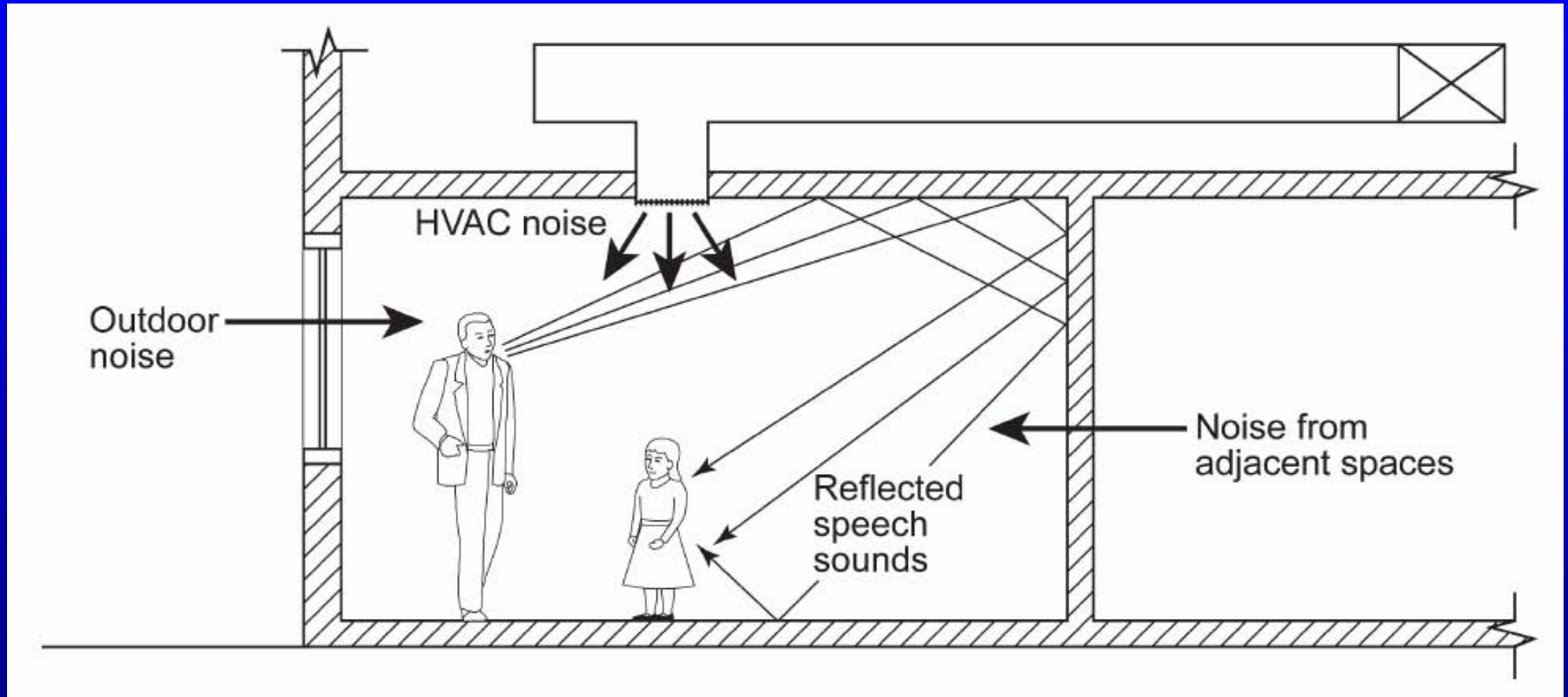
Figure 1: Classrooms with Maximum (left) and Minimum (right) Daylighting in Capistrano

Heschong Mahone Group 2002

Daylighting & Student Performance

In a 2002 multiple building study, Heschong et al identify 7% to 26% higher test scores for school children in highly daylit classrooms than for children in classrooms with no to very little daylighting.

Acoustical Quality, Student Learning, and Teacher Health



Key noise and reverberation sources in classrooms

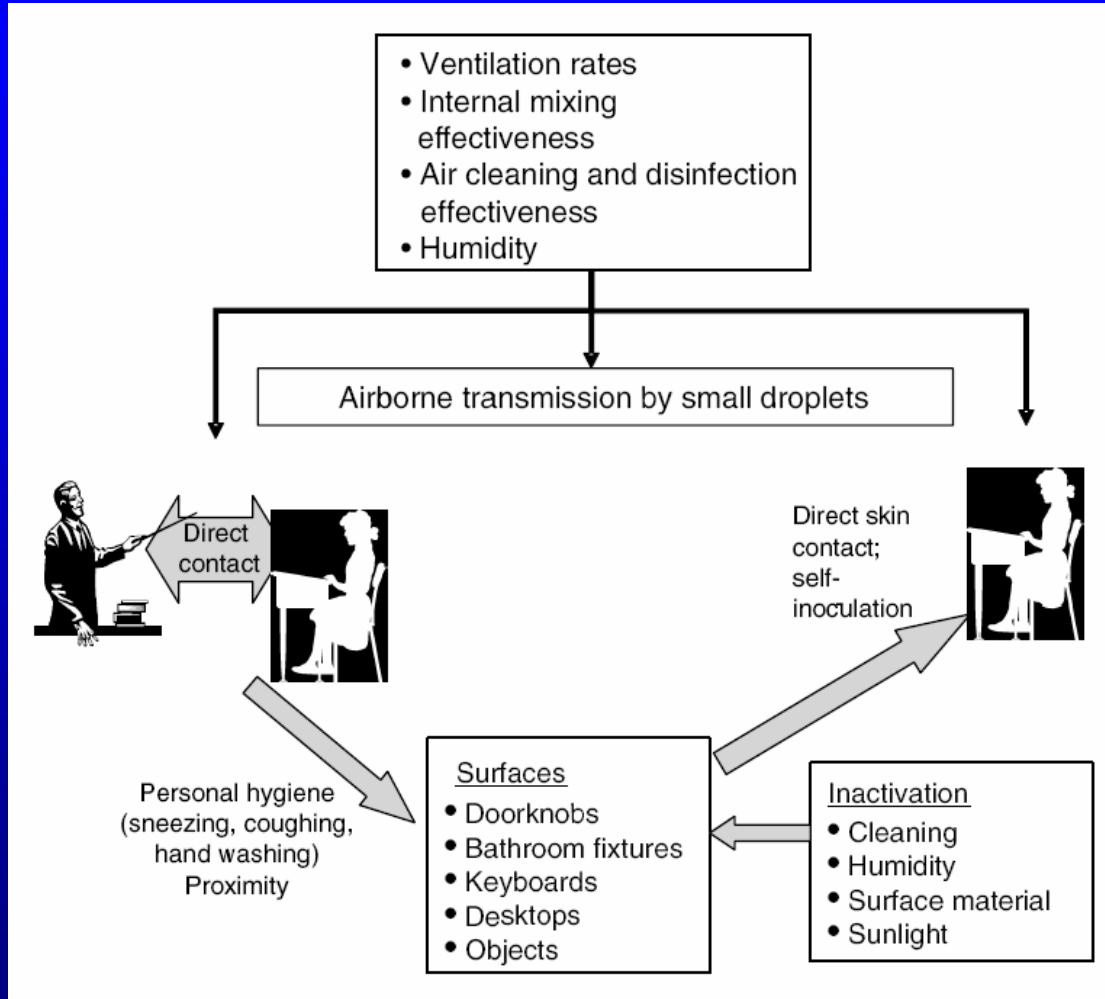
Acoustical Quality, Student Learning, and Teacher Health

- The intelligibility of speech in classrooms is related to the level of speech sounds relative to the levels of ambient noise and to the amount of reverberation in a room.
- Sufficient scientific evidence exists to conclude that there is an inverse association between excessive noise levels in schools and student learning.
- The impacts of excessive noise vary according to the age of students.
- Excessive noise is typically a more significant problem than is too much reverberation in a classroom.
- The most substantial body of research related to noise and learning addresses the impact of road traffic, train and airport noise.
- Some evidence indicates that teachers may be subject to voice impairments as a result of prolonged talking in a noisy school.

Acoustical Quality, Student Learning, and Teacher Health

- Future green school guidelines should require that new schools be located away from areas of higher outdoor noise.
- Future green school guidelines should specify acceptable acoustical conditions for classrooms, e.g. ANSI Standard 12.60, “Acoustical Performance Criteria, Design Requirements, and Guidelines for Schools.”
- Additional research should be conducted to define optimum classroom reverberation times more precisely for children of various ages.

Building Characteristics and the Spread of Infectious Disease



Transmission modes for spread of infectious disease

Building Characteristics and the Spread of Infectious Disease

- The cleanliness of surfaces, relative humidity, and ventilation effectiveness, influence the transmission of common viruses.
- The best way to control infections, especially gastroenteritis, appears to be by instituting procedures that promote good hand cleansing.
- Cleaning of surfaces that are routinely touched (e.g., doors, faucets, desktops) is effective for interrupting the transmission of infectious agents.
- The use of no-touch faucets, doorways, receptacles, and equipment seems to be a reasonable, though unproven, method for infection control.
- Increased ventilation rates have been shown to speed the dilution and removal of viral material. Use of displacement ventilation and reduction of the percentage of re-circulated air in the air supply have the potential to reduce occupants' exposures to airborne pathogens.
- Ultraviolet germicidal irradiation may be effective against some infectious organisms, but its use in schools has not been systematically studied.

Building Characteristics and the Spread of Infectious Disease

- Future green school guidelines should include measures for the regular cleaning of commonly touched surfaces and the availability of hand sanitizers at sinks.
- Full-scale classroom and school studies should be conducted to quantify the efficacy of a variety of ventilation strategies for the dispersion and removal of airborne infectious agents.
- Additional research should be conducted to determine the optimal infection-control interventions in terms of measurable outcomes such as absenteeism and academic achievement.

Overall Building Condition and Student Achievement

- The methodologies used in studies relating *overall* building condition with student achievement are not adequate to determine if there is a relationship between *overall* building condition and student test scores.
- Improved research would measure one or more building performance characteristics, develop a theory linking those characteristics and performance outcomes, and test the linkage using adequate measures of the outcomes and fully specified regression models.

Processes and Practices for Planning and Maintaining Green Schools

- Participatory planning, commissioning, and post-occupancy evaluation can lower building operating costs and improve performance.
- Inadequate planning for schools carries long-term fiscal, human, and academic costs.
- Effective commissioning for green schools requires specific expertise in nontraditional elements such as moisture control, IAQ, lighting, and acoustics.
- Building systems and features should be monitored to maintain performance over a school's service life.
- Post-occupancy evaluations can help to ensure the performance of existing schools and to improve the design of future schools.
- Green schools are a significant public investment, which can be undermined if knowledge or training to appropriately use and operate the school is not provided.

Processes and Practices for Planning and Maintaining Green Schools

- Future green school guidelines should stress the importance of good planning processes that allow for the effective participation of a wide range of stakeholders.
- Future green school guidelines should require a building commissioning process that begins in planning and continues through occupancy.
- Future green school guidelines should encourage the periodic monitoring of indoor environmental characteristics to ensure that performance objectives are maintained.
- Stakeholders should be informed of the design intent of a green school and given the appropriate information or training to use and operate a green school.

Linking Green School to Health and Productivity: Research Considerations

- Multidisciplinary research is required to fully study the potential relationship between a school building and student and teacher outcomes.
- In designing research studies to evaluate the unbiased effects of green schools, several issues must be addressed:
 - Definitions of green schools and of performance/productivity outcomes
 - Full development of a theory explaining links between green school design and outcomes
 - Hypothesis testing to reduce systematic biases
- The committee considers it useful to carry out studies that assess the consequences of the design and construction features as well as building performance characteristics that are associated with green schools using more rigorous study designs.
- Large-scale evaluations using randomized experiments or regression-based techniques should be conducted if they are justified from the results of smaller and less expensive studies.

Yes some performance and/or health links to
Moisture, ventilation, noise, contact infections (mostly non-school studies)



Inconclusive performance and/or health links to
Daylight/ biophilia, thermal, building condition, building as learning tool