Ventilation systems and IAQ in school buildings

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Why do we need a good IAQ at school?

School is the place where young people spend most part of their day and obtaining ad adequate IAQ is a must more than in other environments. In fact young people are more vulnerable to bad environmental conditions than adults since their lugs are still growing up and so, more sensitive to air quality related health problems.

The right of children of having a good air quality at school is recognized worldwide and many efforts are made to assure it. Let us think to the care that WHO shows to this topic with its actions, publications, and sensitization campaigns. That happens because about 300 million people currently suffer from asthma that is the most common chronic disease among children [1]. Furthermore many epidemiological studies have shown that allergic diseases and asthma incidence among young people are growing more and more in these last years [2].

It is important to assure healthy and clean environments to children with these sort of problems since it has been shown that asthma attacks reduce drastically if the exposure to indoor allergens (that may be contained for example, in dust, carpets and furniture, pollution and pets hair), outdoor allergens (moulds and pollens, for example), chemical irritant substances is avoided, or limited, as possible.

Maintaining a good indoor air is important even for the developing of other kinds of troubles. The immediate effect of a poor indoor air quality is appreciable in olfactory discomfort, annoyance concerning stuffy air, and possible irritation of mucosa. Health diseases related to poor indoor air quality, can be simple eye irritation or sense of fatigue but even spread of colds and flu, or of more grievous infections such as the Legionella's disease.

Apart from health diseases, a poor indoor air quality at school is proved to have an effect on learning performance, that is the main task of students in these sort of environments. In particular all of these studies have a common result: the lower is the ventilation rate the lower is learning performance [3], [4].

Which contaminants and which strategies to get their levels low?

Being educational buildings high occupancy environments, human presence and behaviours related pollutants (CO_2, moisture, bio effluents, dust) can be considered as the main indoor sources of contamination there. Anyway, other pollutants shall not be neglected, such as microbial contaminants, volatile organic compounds (VOCs), ozone and plasticizers, mainly emitted by furnishing and equipments. Other kind of contaminants could be present in special areas (such as laboratories and workshops).
All of these contaminants levels shall be maintained as lower as possible by means of proper strategies that can provide:

- the limitation of emissions, where it is possible, avoiding certain kind of sources: let us think, for example, to the choice of new paints, desks or furnishing in a renovation: on the market new low formaldehyde emission materials are disposable, or VOC content labelled materials;
- the removal of contaminants directly on the

source: the correct installation of fume cupboard in chemical laboratories is fundamental, for example;
- the installation of ventilation systems aiming to dilute or remove contaminants.

Some important points are here remarked:
- the choice of the correct strategy for obtaining a good IAQ is different, depending on the particular building and situation;
- whatever is the choice, the ventilation system operation shall not be demanded only to pupils or teachers, but an automatic control is necessary, especially in case of natural ventilation systems. In fact people can adapt to indoor air and the risk is that the need of fresh air is not felt. This happens even because many contaminants are odourless;
- Maintenance and cleanliness of ducts and filters is a key point too, aiming to avoid the development of bad odours, micro organisms' growth and chemical reactions that can result in a poor quality of the supply air.

Which ventilation rates for schools?

The attention to indoor air quality in schools is even shown by the development of many guidelines and regulations concerning the appropriate ventilation rates to be used for these kind of spaces. **Table 1** shows some reference ventilation rates prescribed by some International Standards and EU Countries National regulations for classrooms [2]. In particular, a comparison between the various prescriptions is made considering a 50 m^2 floor area environment occupied by 26 students.

A common experience, anyway is that a big difference can be observed between required and real ventilation rates in these so sensitive buildings. Many studies in the field (see, for example the case study proposed in the following of this issue) have shown that ventilation in classrooms is too poor. One reason is that often schools do not have mechanical ventilation system; furthermore, when mechanical systems are installed, often their bad control leads to very expensive operation, so managers are discouraged to use them, because big ventilation rates means big energy expense and noise, mainly), taking care of safety and energy saving and having special attention to provide easy maintenance.

Which type of ventilation system is the most appropriate for a school? Natural or mechanical? The choice of the most suitable ventilation system is related to many factors such as the type of intervention (new building or renovation), the type of environment (classrooms' needs in terms of ventilation are very different by chemical laboratories ones or gymnasiums), the initial and operation costs and climatic conditions.

Natural ventilation, that is the typical choose for classrooms in warm and hot climate, is the less expensive solution: initial costs are really low if compared to mechanical ventilation systems installations and no energy is required for operation if manual or simple regulation is chosen; maintenance costs are limited as well. In schools budgets are often limited and administrators prefer this choice to others more expensive. Most of the existing school buildings provide fresh air to classrooms and other spaces by means of natural ventilation, not always optimized and limited to operable windows.

Anyway, this kind of system, especially if the strategies of air movement are not optimized, hides a lot of problems. For example, the control can become difficult because of the extremely variable boundary conditions (wind, temperature, pressure…). As a consequence, comfort and indoor air quality are reduced. Indoor air quality can be poorer even because filtering air is difficult to be realized. This kind of system is not applicable during winter in cold climates if an adequate pre-heating of air is not provided.

Installing mechanical ventilation systems is certainly an effective way for reaching a good indoor air quality in classrooms, especially in environments where air-conditioning is required, but costs are often quite high.

This kind of choice is strongly suggested for environments such laboratories, swimming pools, bathrooms and other areas where safety needs have to be satisfied. The choice of mechanical ventilation is convenient even when the outdoor environment is particularly noisy or polluted; in fact, it allows effective filtration and noise insulation. Among advantages of mechanical ventilation systems the possibility of heat recovery is certainly important, because it permits to reach high energy efficiencies.

Table 1. Reference ventilation rates prescribed by International Standards and some EU Countries National regulations for classrooms. From [2].

Type of space	Category	m³/(h occupants)	m³/(h m²)	Qoccupants m³/h	Q building m³/h	Qfinal m³/h
ASHRAE 62/1:2007						
Lecture rooms General		17	1,1			
Occupants: 26 Area (m²): 50				442	55	497
RSECE Dec-Lei 79/2006, Portugal						
General		30				
Occupants: 26				780		780
Building Bulletin 101 v1.4- 5th July 2006, United Kingdom						
General		10,8 – 28,8				
Occupants: 26				281 – 748		281 – 749
		- Daily average value of CO_2 < 1500 ppm (means ≈15 m³/h/person) - Fresh air flow rate calculated as the sum of natural ventilation and mechanical ventilation				
RSDTYP Règlement Sanitaire Départemental Type, France						
Kindergartens, primary schools General		15				
Occupants: 26				390		390
Lyceums General		18				
Occupants : 26				468		468
Finnish Building Code, Part D2, Indoor Climate and Ventilation, Requirements and Guidelines 2003/Danish Building Code						
General		21,6				
Occupants: 26				562		562
EN 15251:2007						
Very low polluting building General	I	36	1,8			
	II	25,2	1,3			
	III	14,4	1,1			
Area(m²): 50 Occupants: 26	I			936	90	1026
	II			655	63	718
	III			374	54	428
Low polluting building General	I	36	3,6			
	II	25,2	2,6			
	III	14,4	1,4			
Area(m²): 50 Occupants: 26	I			936	180	1116
	II			655	126	781
	III			374	72	446
Non low polluting building General	I	36	7,2			
	II	25,2	5,0			
	III	14,4	2,9			
Area(m²): 50 Occupants: 26	I			936	360	1296
	II			655	252	907
	III			374	144	518

As introduced, a great disadvantage of mechanical ventilation systems is the cost: both the initial investment and the operation costs (air movement and maintenance ones) are significant and often they do not meet the schools budgets. That is why the control is fundamental for saving energy in this sort of installations. Demand control systems (based on CO_2, presence, humidity sensors) for these kind of spaces could be a solution for energy efficiency.

Ventilation in schools: where is the solution?

The main aim of a ventilation system, whatever it is and wherever it is installed, is first of all to provide fresh air for the environments, diluting or removing contaminants and so obtaining a good indoor air quality. This aim shall be obtained avoiding discomfort for occupants (absence of draught).

A good solution, in terms of initial and operation costs, especially in case of renovation of naturally ventilated schools could be the mixed mode (hybrid) ventilation system: this allows the ventilation of spaces combining natural forces to mechanical systems. This combination can be obtained, for example, as:

- concurrent operation, when operable windows and mechanical ventilation system work together, in the same space (see **figure 1**);
- change over operation, when, on the basis of boundary conditions the control systems switches on the mechanical ventilation or lets the natural ventilation to work alone (see **figure 2**).
- zoned design, when, for the particular boundary conditions, some parts of the building are served by mechanical ventilation system and others by natural one (see **figure 3**).

Conclusions

The choice and realization of an effective ventilation system for school buildings is related to many factors; main discriminants can be considered: the type of intervention on the buildings, costs, energy efficiency. Then systems and strategies should be realized aiming not to spend too much energy, especially during operation: the fundamental role of control shall not be neglected. Whatever is the choice of designers and managers, health and learning performance of pupil shall always be the main targets.

Figure 1. *Hybrid ventilation system: concept of concurrent operation*

Figure 2. *Hybrid ventilation system: concept of change over operation*

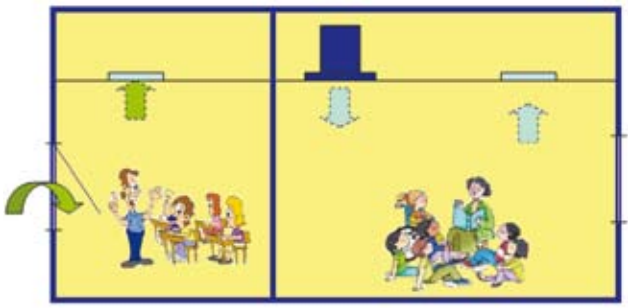

Figure 3. *Hybrid ventilation system: zoned design*

References

[1] http://www.who.int/mediacentre/factsheets/fs307/en/

[2] d'Ambrosio F.R. (ed.) et al. 2010. Indoor environment and energy efficiency in schools. Part 1- Principles. Rehva Guidebook n. 13.

[3] Franchimon F, Dijken F. van, Pernot C.E.E., Bronswijk J.E.M.H. van. 2009. Air-exchange rate under debate. Proceedings of Healthy Buildings 2009, Syracuse, NY, USA.

[4] Daisey J.M., Angell W.J., Apte M.G. 2003. Indoor Air Quality, Ventilation and Health Symptoms in Schools: an Analysis of Existing Information. Indoor Air, 13(1): 53-64.