

## Learning Spaces: Interpreting Domains

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### Abstract

The paper investigates the influence of contextual location of learning spaces for thermal comfort. The paper puts forth comprehensive interpretations of spatial aspects. The study compares two different location of learning spaces in a school building to establish the importance of positioning of classroom placements for enhanced comfort to the users so as to augment learning..

**Keywords:** contextual location, learning spaces, enhanced comfort

### Introduction

Architectural design encompasses different design aspects to bring in enhanced comfort for all the stakeholders. Of all the buildings designed and built, the school buildings hold an important position after residential design as they are occupied by the young generation for almost an equal time spent in homes.

It becomes crucial for the design of school buildings to critically address issues of occupant comfort and to enhance the learning function. Currently most school buildings have classrooms placed in rows abutting single or doubly loaded corridors. Though attention is given to the basic architectural design aspects such as structure, size, daylight and ventilation, the possibility of addressing additional design aspects in totality to enhance functioning needs to be explored.

### Method

**A comparison between two classroom locations in the same building in a school situated in Sagroli, near Nanded, Maharashtra, India is put forth to understand the locational aspect for thermal comfort factor in classroom learning spaces in a building as follows-**

### THERMAL COMFORT:

**Comfort ventilation:** Effective ventilation for comfort is a function of design wind speed as well as its direction relative to opening and the temperature difference between inside and outside. It also depends on the rate of heat gain of a space under reference and the areas of inlets and outlets.

For sizing inlet as well as outlet, for different design wind speeds (m/s) and for the required rate of heat removal ( $W/m^2$  of floor area) and considering the temperature difference between inside and outside of  $1.7^\circ C$  ( $3^\circ F$ ), refer the following table which estimates the size of inlet and outlet as a percentage of floor area. **[Adopted from graph in Sun, Wind & Light, p. 182]**

Wind Speed in m/s	Building's Heat Gain Rate in W/ sq. m. of floor area					
	25	50	75	100	125	150
1	3.5%	7.0%	10.5%	14%	17.5%	21%
2	2.0%	4.0%	6.0%	8.0%	10%	12%
3	1.2%	2.4%	3.6%	4.8%	6.0%	7.2%
4	1.15%	2.0%	3.0%	3.8%	4.7%	5.5%

As can be seen from the table, for wind speed of 1 m/s and for cooling rate of  $100 W/m^2$ , the size of inlet as well as outlet should be 14% of the floor area; whereas, for a wind speed of 2 m/s, the size required is only 8% of the floor area.

Similarly, if the temperature difference is more than  $1.7^\circ C$ , i.e. the outside air is cooler, then the size of opening can be proportionately reduced e.g. if outside temperature is cooler by  $3.4^\circ C$ , then the size of inlet as well as outlet can be halved. In order that ventilation is useful in removing heat from a space, the supply air should be cooler and at a temperature lower than that of the space. Therefore, pre-cooling ventilation air is a prerequisite.

**This can be achieved by using strategies like water bodies with fountains, vegetation or earth / water tube cooling or providing indirect cooling by using a cooling tower and a heat exchanger.**

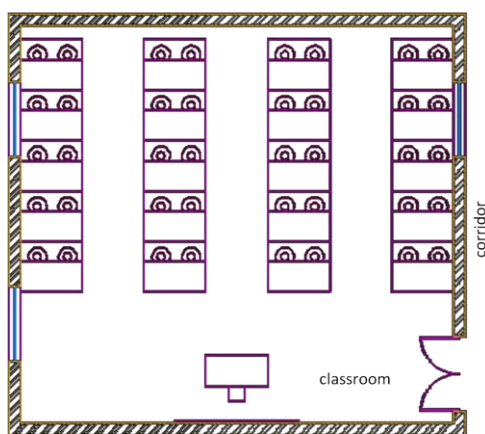
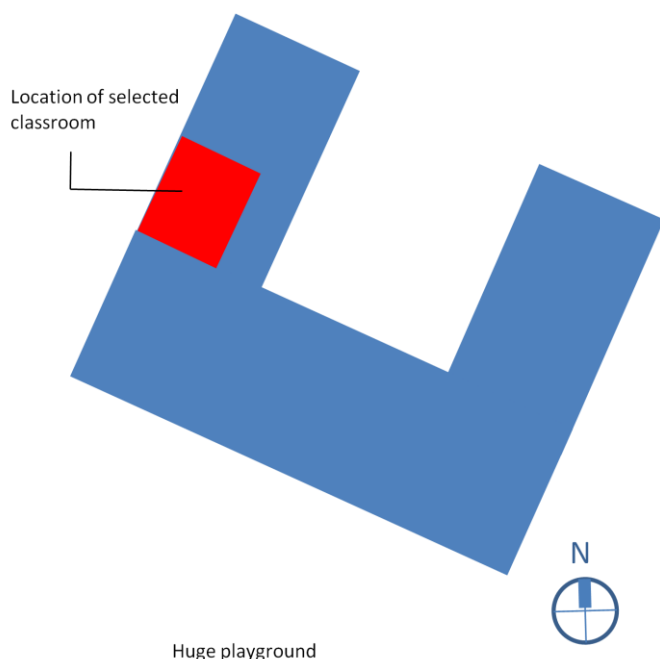
**The amount of sensible heat removed by this flow of outdoor air, in SI units, is given by:**

$$Q = (V) (1.2) (\Delta t)$$

Where Q = amount of heat in watts, V = air flow in Litres per second, and 1.2 is density of air at 1.2 kg / m<sup>3</sup>, multiplied by the specific heat of air at 1.0 kJ / kg K, and Δt is the temperature difference between inside and outside, in °K.

### Location 1: Classroom

The class room is on the ground floor in the western wing



Location 1: Classroom  
 Size :8.4m x 7.9m  
 Ht 3.2m

### Location 1:

Estimated total heat gains i.e. Internal & External heat gains of the class room of 40 students

#### Internal Heat Gains:

1. Heat gains by Occupancy = Heat gain by activity level per person x no of persons = 60 W per person x 40 students = **2400 W**
2. Heat gains by Electric Lighting = Nil
3. Heat gains by equipment = Nil

#### External Heat Gains:

1. **Heat gain through opaque wall:** For this, we have to first find the 'Sol-Air' temperature, for incident radiation value of 248.5 W / m<sup>2</sup> deg C, absorbance factor of the surface as 0.4 and surface conductance of 20 W / m<sup>2</sup> deg C

$$T_s = T_o + (I \times a) / f_o$$

Where, T<sub>s</sub> = sol-air temperature in °C  
 T<sub>o</sub> = outside air temperature in °C  
 I = radiation intensity in W / m<sup>2</sup>  
 a = absorbance of the surface  
 f<sub>o</sub> = surface conductance (outside) in W / m<sup>2</sup> deg C

$$T_s = 39 + (248.5 \times 0.4) / 20 = 39 + (99.42 / 20) = 39 + 4.97 = 43.97 \text{ } ^\circ\text{C}$$

$$\text{Therefore, } \Delta T \text{ for opaque wall} = 43.97 - 24 = 19.97$$

$$Q_c = A \times U \times \Delta T = 25.28 \times 2.44 \times 19.97 = \mathbf{1231.81 \text{ W}}$$

2. **Heat gain through glazing:** For this incident radiation 248.54 W / m<sup>2</sup> (10% of 192 x 12.945), and the solar gain factor of glass as 0.75%

$$Q_s = A \times I \times \theta = 4 \times 248.54 \times 0.75 = \mathbf{745.62 \text{ W}}$$

3. **Heat gain due to ventilation:** For this we will consider 1300 J per m<sup>3</sup> deg C as the volumetric specific heat of air, 2.362 as the ventilation rate in m<sup>3</sup>/s, and 15 °C (39 - 24) as the temperature difference between inside and outside

$$Q_v = 1300 \times V \times \Delta T = 1300 \times 2.362 \times 15 = \mathbf{46059 \text{ W}}$$

Therefore,  
 the total heat gains = 2400 + 1231.81 + 745.62 + 46059 = 50436.43 W, say **50.44 kW**

**This is a tremendous heat load for the class room.**

However, if a 20 to 25 m wide thick swath of vegetation on North West side of the building is provided, then the outside air will be 5 to 6 °C cooler than the ambient air resulting in the reduction of almost 15.35 kW.

$$(Q_v = 1300 \times V \times \Delta T = 1300 \times 2,362 \times 10 = 30706 \text{ W} = 30.71 \text{ kW instead of } 46.1 \text{ kW})$$

Additionally, if a water body ahead of this vegetation, towards the windward side, of size say 200 m<sup>2</sup> (25 x 8 m) is provided

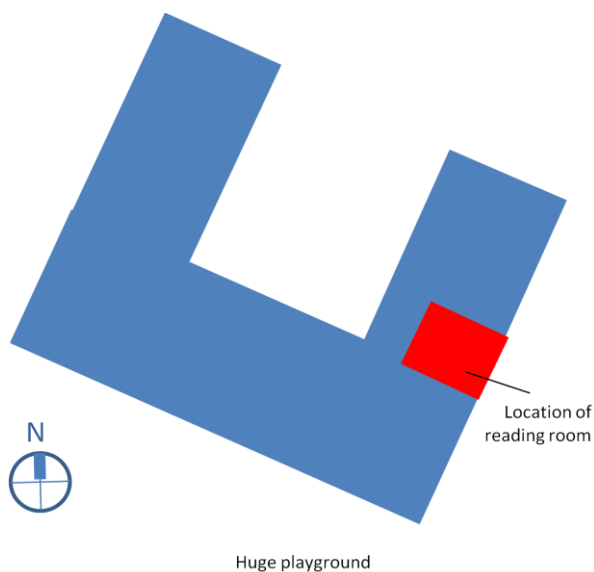
then it is able to reduce this heat load further by 40 kW, with an evaporative cooling rate of 200 W per m<sup>2</sup> of water body.

$$(200 \times 200 = 40000 \text{ W} = 40 \text{ kW})$$

With a total heat reduction by 55.35 kW, to create comfort condition for the class rooms on North West side can be created.

**Location 2:**

The reading room is on the first floor of the school building in the eastern wing



**Internal Heat Gains:**

1. Occupancy Heat Gain = 24 x 60 = 1440 W
2. Heat gains by Electric Lighting = Nil
3. Heat gains by equipment = Nil

**External Heat Gains:**

1. Heat gain through opaque wall =  $A \times U \times \Delta T = 17.92 \times 2.44 \times 19.97 = 873.18 \text{ W}$
2. Heat gain through glazing =  $A \times I \times \theta = 2.4 \times 248.54 \times 0.75 = 447.37 \text{ W}$
3. Heat gain due to ventilation =  $1300 \times V \times \Delta T = 1300 \times 0.7086 \times 15 = 13817.7 \text{ W}$

**Total Heat gains = 1440 + 873.18 + 447.37 + 13817.7 = 16578.25 W = 16.58 kW**

**This heat load can be reduced by thick swath of vegetation in the central space.**

**Discussion**

It is seen that the classroom Location 1, is larger in size than the reading room at location 2 in the school building and has a tremendous heating load to be addressed to make the occupants comfortable.

The comparison shows that the reading room at Location 2 in the school building is more comfortable for the thermal comfort criteria.

The comfort level of the occupants can be enhanced by addressing orientation of the classroom, size of window openings (outlet and inlets), location of window openings, the immediate green cover and presence of water bodies. But most importantly by giving due attention to the location of the classrooms in the building.

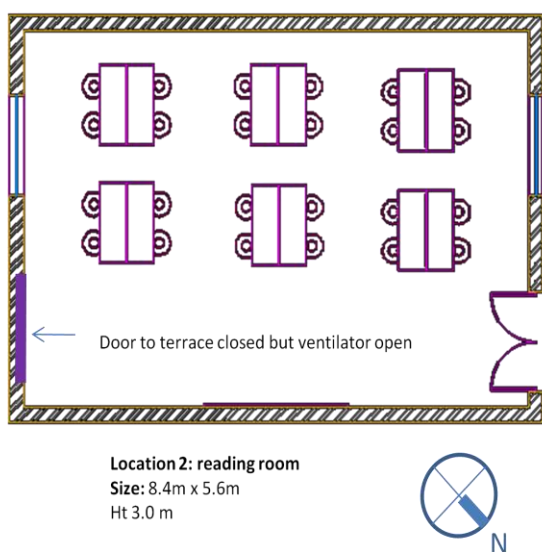
**Conclusion**

The study illustrates that spatial aspect of locating a learning environment is crucial for the function of learning to take place comfortably.

Bill Hillier has put forth that ‘buildings are among the most powerful means that society has to constitute itself in space-time and through this to project itself into the future’. It becomes pertinent to critically address the design of school buildings which is used by the young generation, the future citizens of society.

**References**

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**Location 2:**