

**SUSTAINABLE SCHOOLS  
PLANNING LEBANON  
ENVIRONMENTAL AND  
FINANCIAL BENEFITS**

**AN IMPORTANT GUIDE TO TAKING ACTION**

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# TABLE OF CONTENT

ABSTRACT .....	2
INTRODUCTION .....	2
SUSTAINABLE DEVELOPMENT MODELS .....	3
CASE STUDIES .....	8
DESIGN OF A SUSTAINABLE SCHOOL AND STRATEGIES .....	11
ENVIRONMENTAL AND FINANCIAL BENEFITS .....	23
CONCLUSION .....	26

# ABSTRACT

In order to promote sustainability, schools can be designed in a new fashion that conserves the energy cost and reduced resources needed. The design must take into account the different theories for sustainability. It must also take into account similar cases that were done. For green and sustainable schools, strategies must be implemented in order to ensure a better environment. If these measures are taken, financial benefits and schools can conform more to the requirements of sustainability.

## INTRODUCTION

“A school is a symbol of the community in built form; functionally it should be extended and promoted as place of community assembly”. (Alberta Ministry of Infrastructure Technical Services Branch, 2012) A school should create an environment which enhances the lives of its users (Ibid).

Sustainability in all domains of life has ceased to become an option when we have long reached critical crisis point with regards to the integrity of our planet and its resources. In a report published in 2017 by the International Energy Agency, the building sector made up 30% of the global energy consumption and 55% of the global energy demand. If combined with the building sector, the percentage goes up to 36% of all energy consumption and becomes responsible for 40% of the global carbon dioxide emission.

The situation is expected to become worse with an average increase in energy consumption in buildings by 1%/year, 2.5% of electricity use and 1% carbon dioxide emission (Energy Technology Perspectives, 2017).

# SUSTAINABLE DEVELOPMENT MODELS

In response to this crisis, sustainability emerges as the logical solution. There are many definitions of sustainability, but the most accepted one is “the simple idea of ensuring a better quality of life for everyone, both now and for generations to come, and meeting the needs of the present without compromising the ability of future generations to meet their own needs” (WCED, 1987). The topic being discussed is related to the sustainability of schools, and they have received much attention as being the learning centers and living spaces of developing minds.

## I. Five Pillars

## II. Egan Wheel

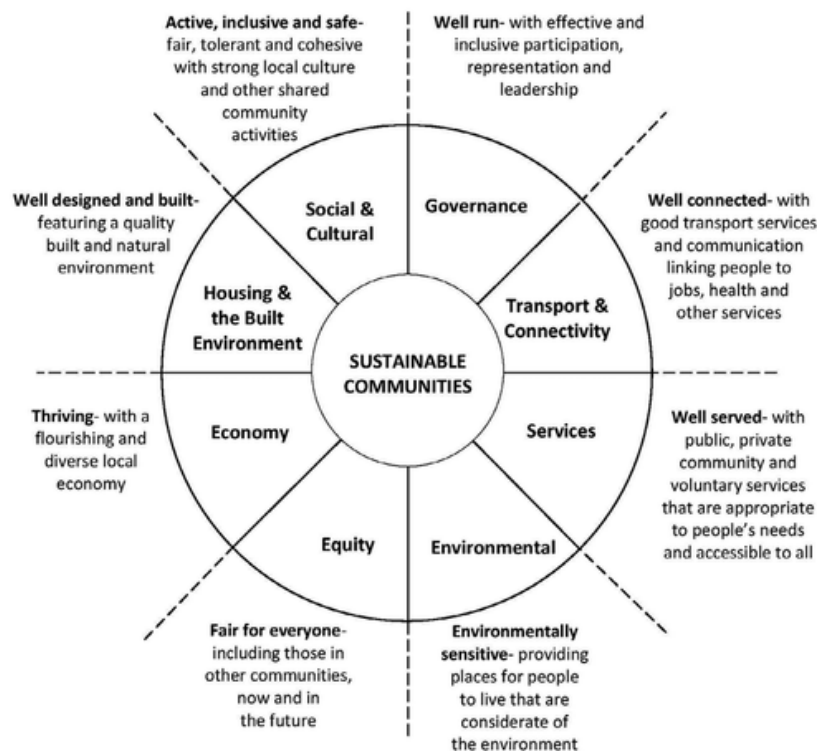
## III. The Eight Doorways

## I. Five Pillars

The five pillars of sustainability according to the UK government's vision for sustainable developments are as follows:

- The natural environment
- Economy
- Society
- The use of good governance
- The use of sound science (UK Government, 2005)

## II. Egan Wheel



The Egan Wheel of Sustainability is another well-accepted indicator of sustainability claiming that “sustainable communities do not come by chance and we must work to create them and the report introduces key components of sustainable communities” (Dias et al., 2014).

Therefore, schools play an important role to ensure sustainable communities and this will be shown while discussing the 8 Doorways of sustainable schools in the following part.

### III. The Eight Doorways

The Department of Children, Schools and Families (June 2009) developed eight doorways to sustainable schools. It was developed with the following recommendations (Briney et al., 2011):

#### 1. Food and drink:

Providing students with a healthy diet, show “strong commitments to the environment, social responsibility and animal welfare”, “maximize the use of local suppliers”.

**Application:** Barking Abbey School Secondary school, London Borough of Barking and Dagenham: the kitchen waste is used as fertilizers and therefore waste is reduced and it has a gardening club where the school produces its own goods. (Government Office for London, 2007)

#### 2. Energy and water:

Teaching students to properly manage water intake for preservation, use renewable energy like “wind, solar and biomass energy”, use “insulation and low-power technologies”, use “rainwater harvesting, grey water recycling and sustainable drainage systems” and apply energy management.

**Application:** Stanley Park Junior School Primary school, London Borough of Sutton: usage of pushbutton taps and efficient flush mechanisms; in addition to raising awareness among pupils about water conservation. (Government Office for London, 2007)

### 3. Travel and traffic:

Encouraging students to adopt green practices such as riding bikes and carpooling.

**Application:** Hackney Free and Parochial Secondary School, London Borough of Hackney: as a sustainable alternative means of transportation, cycling and walking are highly encouraged: they provided cycling lanes and racks, made the vehicular road one-way and added speed bumps, (Government Office for London, 2007)

### 4. Buildings and grounds:

Designing the school in a way that sustains the resources of Earth

**Application:** Ashburton Community School Secondary school, London Borough of Croydon: improve the performance of the building through active and passive strategies: by using PV cells, automated windows, rain harvesting systems and maintaining indoor thermal comfort. (Government Office for London, 2007)

### 5. Inclusion and participation:

Making sure each student is accepted and feels safe to express their thoughts

**Application:** Ravenscroft School Secondary school, London Borough of Barnet: sustainability plans created by the students for their school and for their community. (Government Office for London, 2007)

### 6. Purchasing and waste:

Teaching students to reuse material and minimize expenditure.

**Application:** The City of London Academy Secondary school, London Borough of Southwark: the school works on changing the behavior of students: students are consuming efficiently which reduces waste. In addition to, recycling whenever possible which has provided a recycling service for local businesses. (Government Office for London, 2007)

## 7. Local well-being:

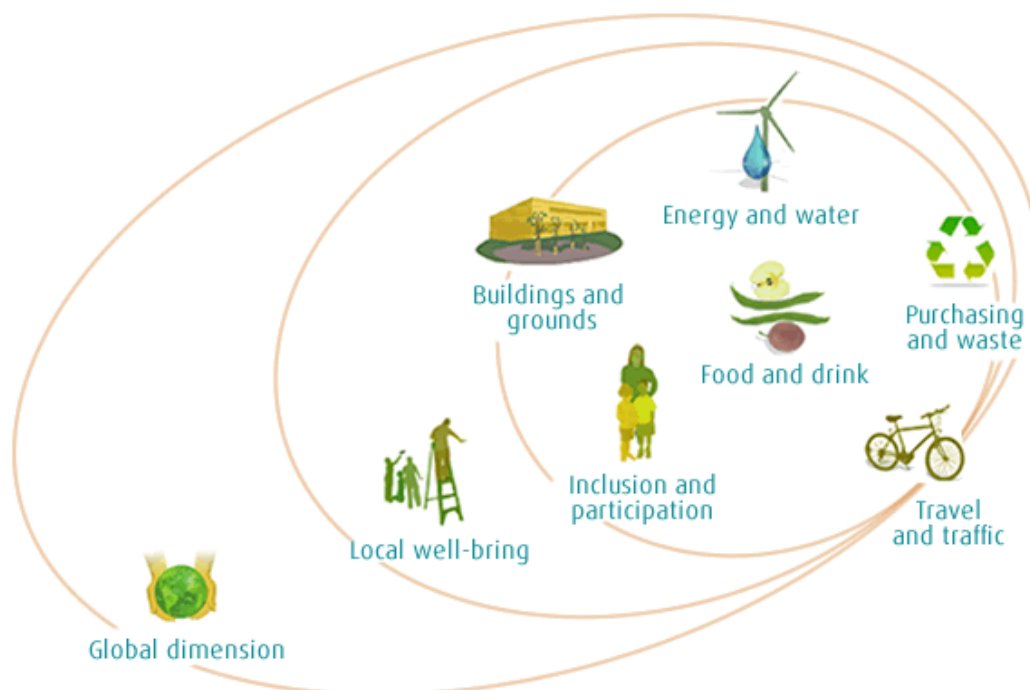
Giving students a sense of their community and helping them get more involved

**Application:** the Petchey Academy Secondary school, London Borough of Hackney: help improve the environment and the local quality of life by initiated activities prepared by the school. Moreover, it included extra hours for an extended curriculum related to sustainable issues. (Government Office for London, 2007)

## 8. Global dimension:

Raising awareness of just how interlocked the world is and that we share the same fate.

**Application:** Lampton School Secondary school, London Borough of Hounslow: it has a mixed-cultural intake of students and it raises money for international environmental and social issues. (Government Office for London, 2007)



The Sustainable Schools strategy is made up of eight sustainability 'doorways'.

Reference: Nationalcollege For School Leadership <https://www.nationalcollege.org.uk/transfer/open/csbm-managing-the-school-environment/csbm8env-s2/csbm8env-s2t3.html>



# CASE STUDY 1

“

This project has earned a BREEAM Outstanding Award for Highest Scoring Project in the Education Sector because of its innovative approach to community energy distribution.

**Project:** North London, the Couch Hill Community Park is the first building with BREEAM certification.

**Strategy:** Energy and water efficiency Starting by the heat power, the gas CHP network delivers both heat and electricity for the school and any excess of heat is being exported. The usage of low-energy lighting systems with solar glazing and shading devices tailored to particular orientation of elevation.

Concerning the water efficiency, all the rain water is being collected. Also the Ecoplaycisterns are used to collect grey water from showers and wash hand basins in the toilets and later for flushing toilets.

”

“

This school has been selected among the AIA COTE top ten awards 2018. (AIA, 2018)

**Project:** Mundo Verde at Cook Campus, Washington, DC

**Strategy:** Environmental issues, this is mainly seen in the rain harvesting system. The elementary play area is encircled by a constructed stream bed. It is fed in part by a hand pump designed for educational water play, and it terminates into a rain garden. Through this system, third graders learn about the water conservation and about water cycle. (AIA, 2018)

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Mundo Verde at Cook Campus Source: <https://www.archdaily.com/785416/mundo-verde-bilingual-public-charter-school-studio-twenty-seven-architecture>

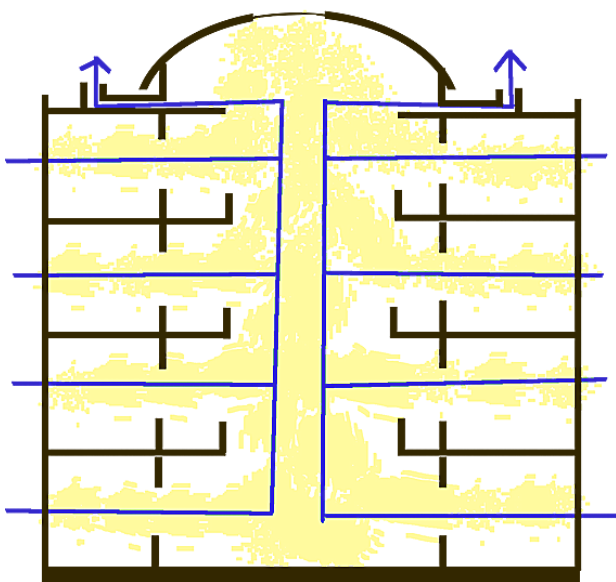
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This building adopted sustainable design strategies to become LEED certified and to be 40% more efficient than required by the Oregon Energy Code.

**Project:** Lillis Business Complex – University of Oregon

**Strategy:** The building is oriented on an east-west axis where the south façade that has photovoltaic panels receives a lot of sun exposure. Moreover, solar control is easier on the north and south facades. Its atrium is allowing natural ventilation and natural lighting: this is coupled with automated louvers and openings to maximize the efficiency of the system both for heat and cooling. The Light shelves allow solar control and reflect the sun light enhancing day lighting in the classrooms. (Kwok and Grondzik, 2007)

”



 Natural ventilation through the atrium

 Daylight penetration



Lillis Business Complex-University of Oregon-  
Source: <https://around.uoregon.edu/content/construction-lillis-business-complex-part-biggest-building-boom-uo-history>



# DESIGN OF A SUSTAINABLE SCHOOL AND STRATEGIES

To further define the vision of a sustainable school in a Lebanese context with its priorities and corresponding strategies.

## I. Lighting

- a. Daylight Factor
- b. Side-Lighting
- c. Top Lighting
- d. Light Shelves
- e. Shading Devices
- f. External and Internal reflectance
- g. Orientation- Location of functions
- h. Artificial Lighting

## II. Cooling

- a. Controlled Natural Ventilation
- b. Stack Ventilation
- c. Night Ventilation of Thermal Mass
- d. Cross Ventilation
- e. Mechanical Ventilation

## III. Heating

- a. Direct gain-Glazing
- b. Indirect gain-Wall
- c. Indirect gain-Roof

## IV. Water and Waste

- a. Rain harvesting
- b. Previous surfaces
- c. Water reuse

## V. Acoustics

## VI. Envelope

- a. Choice of materials
- b. Insulation materials

## VII. Massing

- a. Atrium
- b. Spine/Street
- c. Strawberry-Learning Cluster
- d. Courtyard

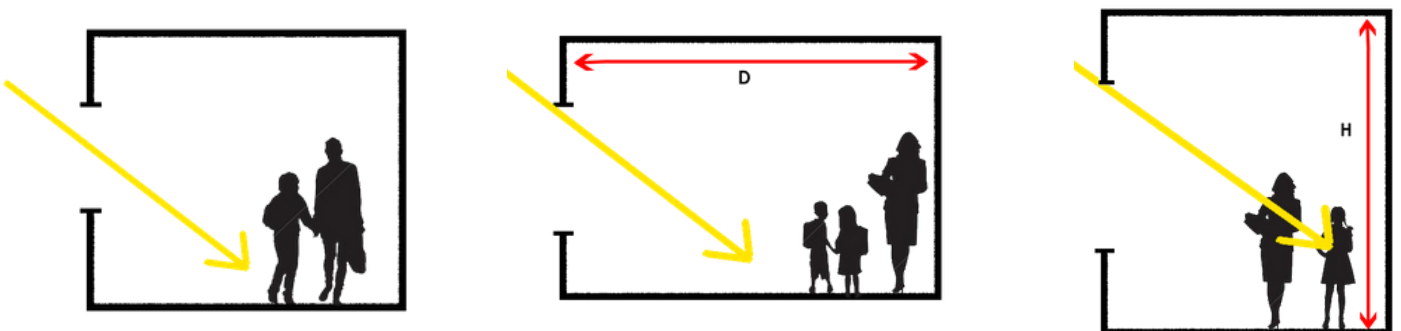
# I. LIGHTNING

## a. Daylight Factor

Proper daylight is important since the school is a place of learning, reading and writing. The average daylight factor required for schools is 2%. (BRE, 2018b) It depends on the following: orientation, size and location of daylight aperture, room dimensions, external and internal reflectance, and effect of daylight enhancement strategies (Kwok and Grondzik, 2007:58). The minimum area that should comply with this factor is 80%. (BRE, 2018b)

## b. Side-Lighting

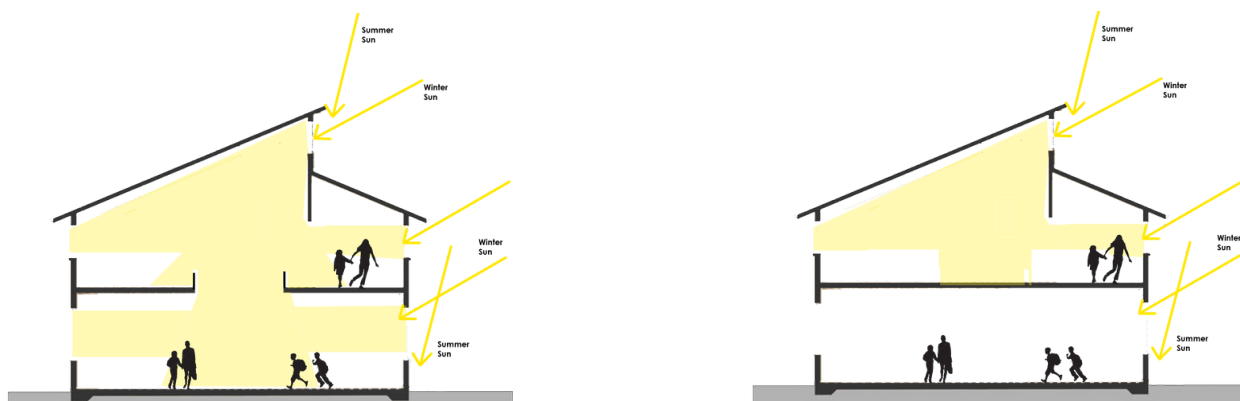
Windows sizing is dependent on the required daylight factor, width, depth and height of the room. The deeper the room, the larger the window size. They should not be oversized to prevent heat losses in winter and heat gains in summer. Therefore, adjustable window shading is the ideal situation (UK Department of Education, 1998).



Windows sizing is dependent on the required width, depth and height of the room.  
Diagram by authors

### c. Top Lighting

In the case of top-lighting, voids are important in order to allow light to penetrate to lower levels and to ventilate the the building.



Deeper Light penetration using roof lighting and voids.  
Diagram by authors

### d. Light Shelves

In the school's design, light shelves are useful since they evenly distribute daylight entering through windows. They also reduce glare (UK Department of Education, 1998; Kwok and Grondzik, 2007).



Light shelf evenly distributing light in the classroom while reducing glare.  
Diagram by author

### e. Shading Devices

Overhangs, external shading, recessed windows are all useful to avoid excessive heat gains in the summer with the south-east dominant orientation.

### **f.External and Internal reflectance**

Limiting or enhancing the reflection of light is related to the choice of finishes of the exterior and interior spaces. However, during the day, smooth light-colored finishes for classrooms interior walls will definitely reduce the need for artificial lighting. (UK Department of Education, 1998)

### **g.Orientation- Location of functions**

South-East is the favored orientation for schools since it can take advantage of reducing summer overheating and solar gains for heating/lighting. Rooms that are used permanently should be 30 degrees from south (towards east) and, according to the Building Handbook, a Guide to the Energy Efficiency of Educational Buildings (UK Department of Education, 1998), orientation could be as follows:

- Classrooms, staffrooms and offices should be oriented towards the South or South-East. Frequently used therefore solar gain for heating and lighting should be maximized.
- Art rooms and Workshops should be oriented towards the North
- Gym, Theater and Hall should be oriented towards the North, North-East or North-West
- Kitchen and Toilets should be oriented towards the North, North-East and North-West
- Library should be oriented towards the North or North-East
- Changing rooms should be oriented towards the North

### **h.Artificial Lighting**

25% of all energy consumption in the school is around electricity and 75% of expenditure on energy fuels. Installing movement or sound detectors in certain hallways and automatic daylight sensors, should be implemented for dimming in classrooms. (UK Department of Education, 1998)

## **II. COOLING**

### **a.Controlled Natural Ventilation**

In order to prevent condensation caused by humidity, ventilation is indispensable. The school should rely on natural ventilation for most of the year. Opening and closing windows should be ensured. Trickle vents can be implemented in the school too. (UK Department of Education, 1998).

### **b.Stack Ventilation**

“Stack ventilation is a passive cooling strategy that takes advantage of temperature stratification.” (Kwok and Grondzik, 2007: 145) Heat is radiated by a large number of people that occupy the school, and hot air will need to be evacuated from the building. In stack ventilation, cooler denser air is usually drawn in at lower levels, and light hot air rises from the floor and exits the building through high outlets.

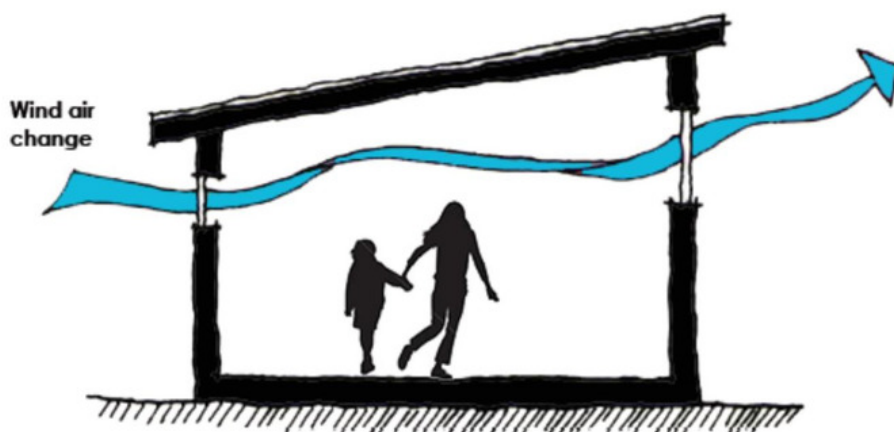


### c. Night Ventilation of Thermal Mass

If in some Lebanese school stone walls are used for main functions, night ventilation of thermal mass is essential. These walls would absorb heat, and store it, during summer. At night, this stored heat would be released and ventilation of the building would allow the released heat to exit the school, since the outdoor temperature would be cooler than the indoor temperature. (Kwok and Grondzik, 2007)

### d. Cross ventilation

Cross ventilation is when a flow of air enters a building, and exits it from another point; thus carrying heat to the outside. The size of openings, the wind speed, and the outdoor temperature are cooling-related (Kwok and Grondzik, 2007:139).



Cross ventilation.  
Diagram by author.

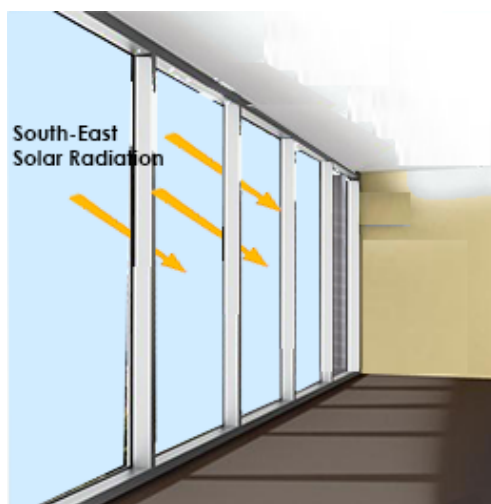
### e. Mechanical Ventilation

In school areas with a high number of people, such as classrooms, halls, auditoriums, etc. and where the interior or exterior temperature reaches a predetermined maximum, mechanical ventilation is needed with natural ventilation (UK Department of Education, 1998)

## III. HEATING

### a. Direct gain-Glazing

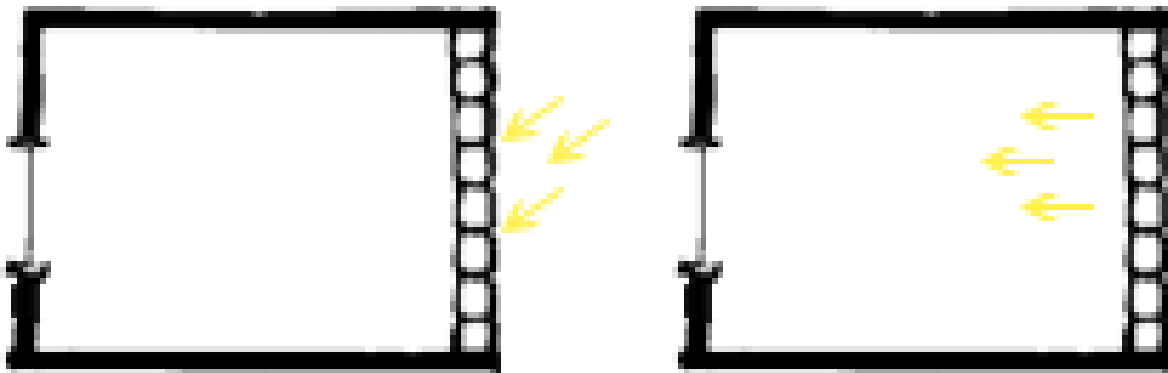
Passively heating the school's space could be done by direct solar gain from the South-Eastern openings which is very effective (Kwok and Grondzik, 2007: 107). In summer, by using proper shading, solar gain can be easily controlled (see 1.5 Shading devices)



Direct gain from southern glazing.  
Diagram by author.

### b. Indirect gain-Wall

Local material, stone, is preferably used for classrooms since in winter, thermal mass materials can absorb solar energy and store it; thus heating the spaces throughout the afternoon. However, they would serve to delay heat losses from the spaces. When the space is no longer in use, the heat escapes at later stages. In summer, thermal mass walls delay heat transfer from the exterior to the interior (Kwok and Grondzik, 2007: 113).



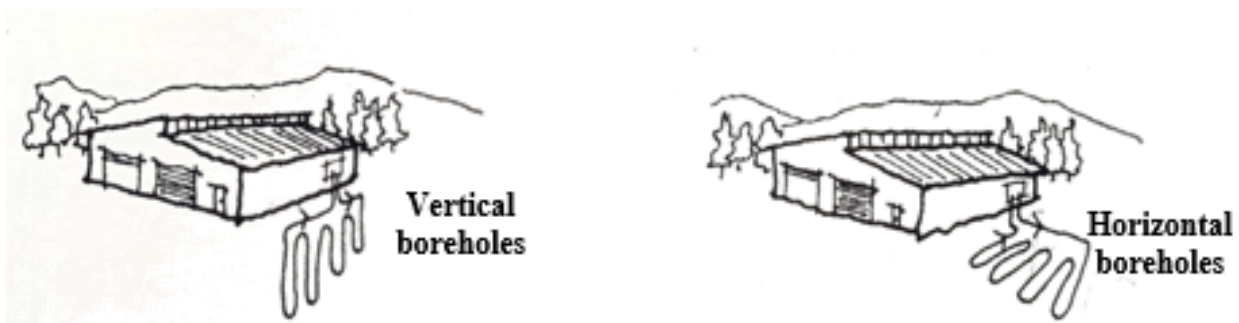
Thermal mass storing and delaying heat transfer from the exterior to the interior.

### c. Indirect gain-Roof

The roof is the key to the conservation of heat in Lebanon. Therefore a thermal storage roof, such as a shallow pond of water, could be useful in controlling heat escaping from the roof. During the day, it can have a movable insulation adjusted to expose the thermal mass. During the night, it can be enclosed in order to prevent heat losses. To efficiently heat the space, an auxiliary system would be needed. In summer, the thermal mass roof system benefits from the cool night sky (Kwok and Grondzik, 2007: 113).

#### d. Ground source heat pumps (Air to water)

A ground-source heat pump will aid this thermal storage roof. In order to heat the building, it uses the stable temperature of the earth in surrounding lands. In the case of Lebanon, since increasing urban expansion is happening, deep boreholes are implemented instead of horizontal loops. This would allow for future site development. Moreover, a deep excavation of 45-140m in the ground is required. (Kwok and Grondzik, 2007: 131-133)



In order to allow future expansion of the building, vertical boreholes are used instead of horizontal ones.

Source: Kwok and Grondzik, 2007:132

## IV. WATER AND WASTE

#### a. Rain harvesting

One of the design considerations is rainwater harvesting. In order to teach students about water collection, water harvesting volumes would be present on site.

#### b. Pervious surfaces

Water infiltrates into the soil and vegetation grow within them when ensuring pervious surfaces. In addition to, increasing land cover on site.

**c. Water reuse**

“the reutilization of water for any application other than the original use” defines water reuse. Waste water from the school’s lavatories and showers in gyms is called grey water... Moreover, it is not contaminated by human waste. This same water could be reused for the maintenance of the ground source pump system and for irrigation (Kwok and Grondzik, 2007:233-237)

## V. ACOUSTICS

**Acoustical tiles**

The goal is to treat noise by separating quiet areas (classrooms, workshops....) from noisy ones (cafeteria, playgrounds...). In the case of stone walls classrooms, these particular walls would not allow proper transmission of sound. Therefore, the use of tiles is needed. In order to absorb reverberations and enhance the overall acoustics for auditoriums and lecture halls, the design of non-parallel walls is needed.

## VI. ENVELOPE

**a. Choice of materials**

The choice of materials for different spaces is related to the frequency of use of the space. Heavyweight materials are assigned for areas with continuous use since the heat transfer property of thermal mass is delayed. Thermally light-weight materials are preferably assigned for spaces of intermittent use.

**b. Insulation materials**

To minimize ventilation heat losses, the building should be sealed. In order to decrease the risk of interstitial condensation and avoid it, the usage of proper thermal insulation, joint finishing and movable shading for windows would be beneficial.

## VII. MASSING

Based on Alberta Ministry of Infrastructure Technical Services Branch, 2012, schools' typologies are the following:

### a. Atrium

A main active space of social and visual interaction is provided by the atrium typology. Natural daylight is increased and cooling through stack effect is enhanced. As for its disadvantages, overheating may be caused and it may require vertically layered functions, which may not be ideal for schools in terms of accessibility.

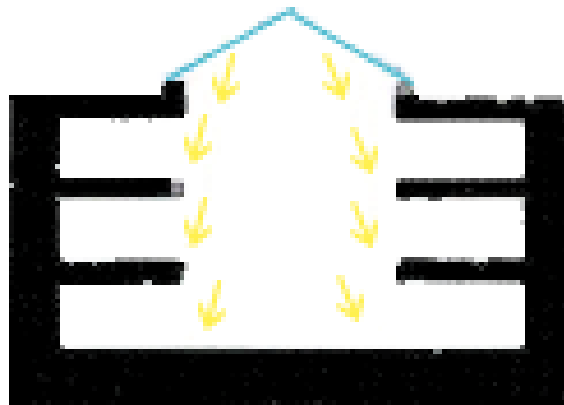


Diagram by author

### b. Spine/Street

This typology allows the use of skylight, makes way for future development and minimizes circulation. As for its disadvantages, if it is not properly oriented it may become a wind tunnel. In addition to, the distance (main entrance - last function) might become long.

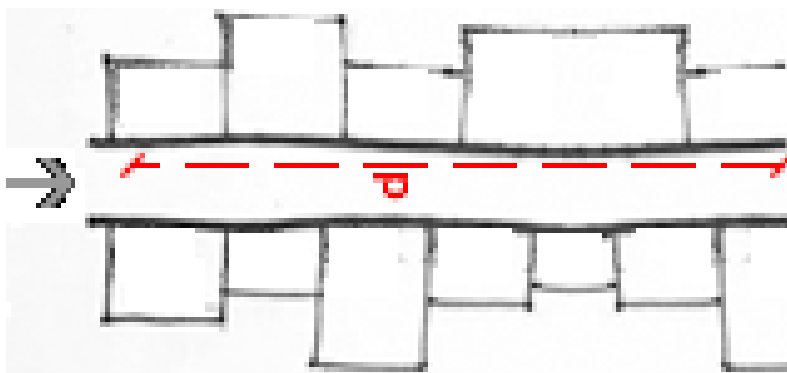


Diagram by author

### c. Strawberry-Learning Cluster

This typology ensures smaller groups of students and human-scale clusters. It enhances participation and daylighting through slits in the circulation. It could benefit from a South-Eastern orientation by tilting the classroom clusters. As for its disadvantages, it has more exposed surface area which means greater heat losses.

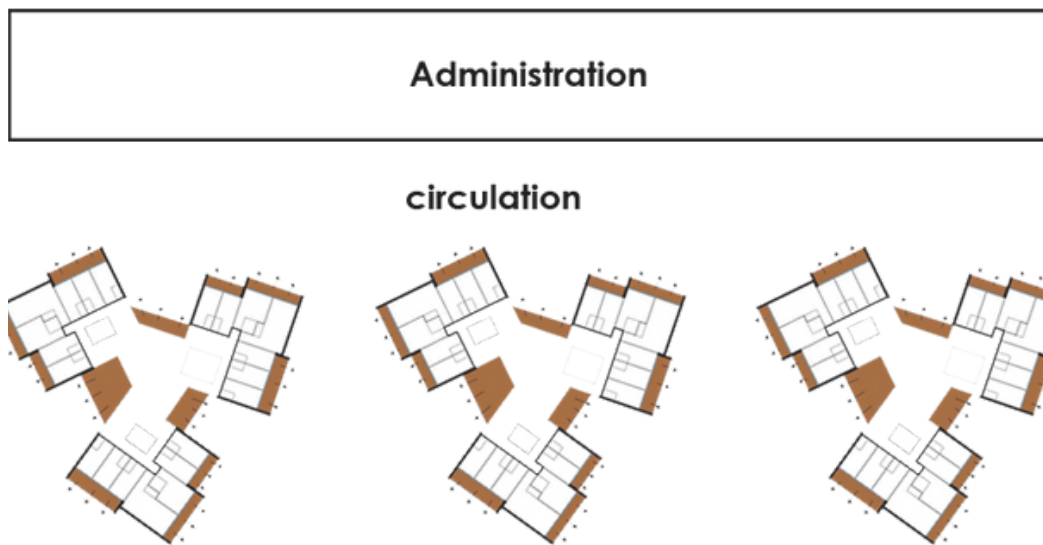


Diagram by author

### d. Courtyard

This typology allows the creation of a controllable micro-climate, daylight penetration, ventilation, feelings of security and visual comfort. As for its disadvantages, it demands more exposed surface area and longer circulation spaces.

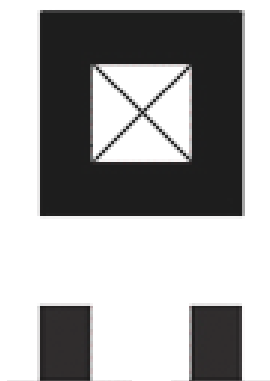
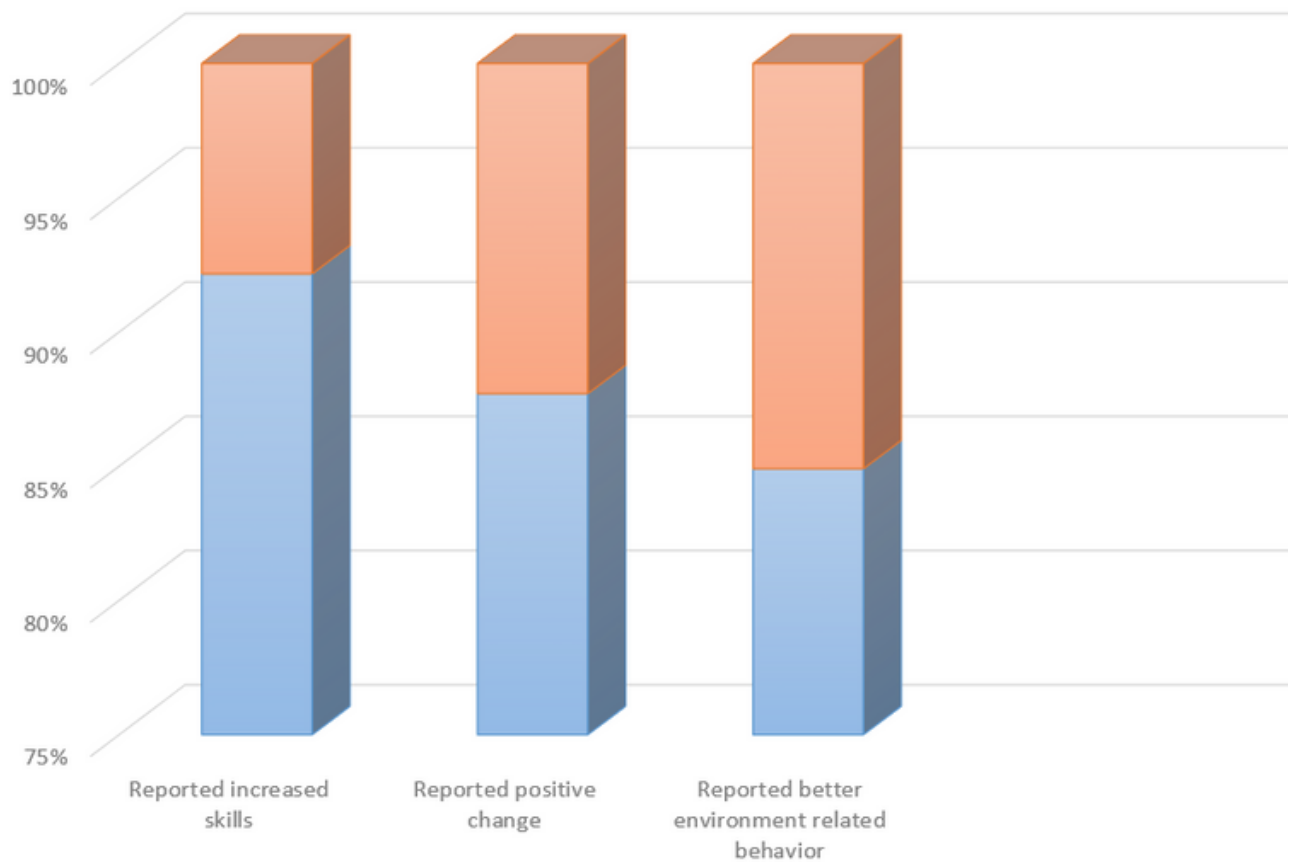


Diagram by author

# ENVIRONMENTAL AND FINANCIAL BENEFITS

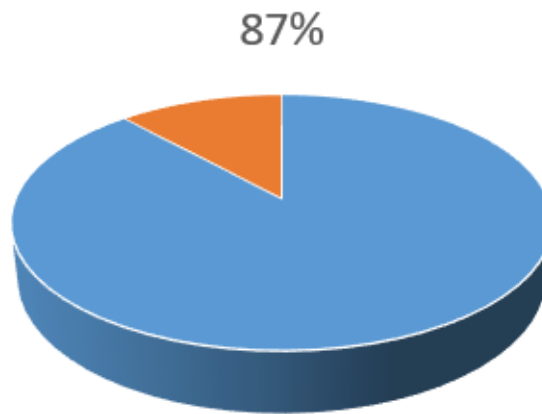
UN Sustainable Development Goals by 2030: Without acknowledging the important connection between educational development and a sustainable learning environment, the plan of action for people, planet and prosperity cannot be met. Therefore, one can clearly realize the positive impact of a good environmental education on students, as seen in the chart below.



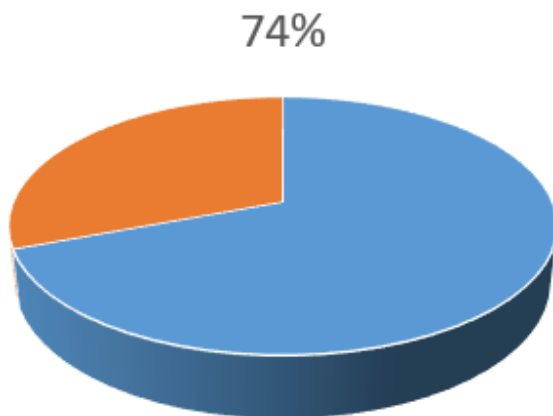
Impact of Environmental Education on students (Source: NAAEE Case Study)



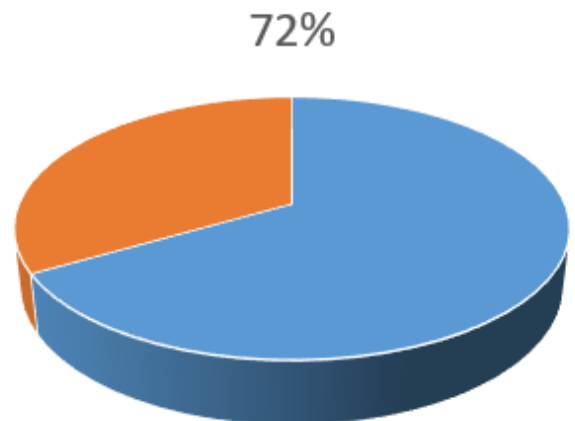
That is why sustainable schools are important.  
Executive views on green school performance compared with conventional schools:



**Reduced Absenteesism**



**Ability to Attract/Retain Teachers**



**Improved Community Image**

Source: Greening America's school (2006)

## Environmental Benefits:

- A reduction, on the streets surrounding the schools and in the district, in the amount of litter. (Healthy living & Litter)
- Traffic congestion reduced and increased safety surrounding the schools. (Transport)
- Improve district recycling rate use of recycling facilities by increasing awareness and the use of recycling facilities. (Waste)
- Increase outdoor green areas and the use of leisure facilities via the healthy living aspect of sustainable schools. (outdoor learning & healthy living)
- Reduction in pollution levels through the district by reducing the energy consumption within and the schools and pupils' home. (energy)
- Water consumption reduction through rain harvesting and water reuse. (water)

Sustainable schools use 33% less energy and 32% less water than conventionally constructed schools. (Source: UN Sustainable Development Goals) 38.5% reduction in asthma (number 1 reason for students absence in U.S.

## Financial Benefits:

- Sustainable schools, on average, 100,000\$ per year on operational costs.
- Sustainable school receive direct and indirect savings from increased efficiency, higher teacher retention, and lower health costs, saving about 70\$ per square foot, 20 times higher than the initial "greening" costs. (Source: UN Sustainable Development Goals)

## CONCLUSION

Different models exist when designing for sustainable schools such as the five pillars, the Egan Wheel, the eight doorways to sustainability, AIA guidelines, among many others. There is much that can be done to convert the school into a green design that is eco-friendly and sustainable. Schools are the boarding place for the next generation's success, so rehabilitating them must be a priority.

The sustainability of our schools has a large impact on sustainability of our communities and planet. Providing passive heating or cooling by a simple design strategy, for example, it reduces the ecological footprint of a building and the emission of greenhouse. Therefore, this is affecting the direct context as well as the global one and the design decisions. One can simply conclude that designing for sustainability is not a linear process rather an endless cycle that demands further research.

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