Daylighting Analysis of a School Building Using Simulation Technology

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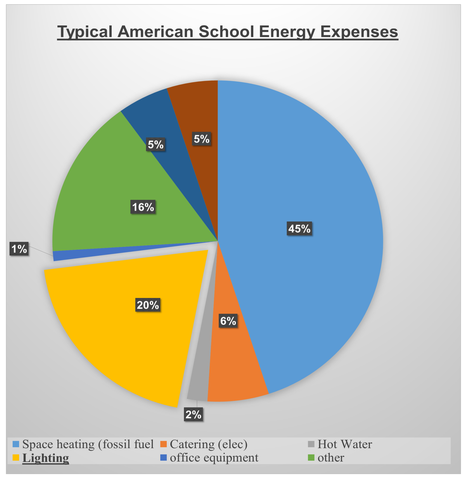
Introduction/Background

Lighting is one of the most flexible factors of a building. A building can be lit from a number of sources such as light bulbs, skylights, and windows. In terms of efficiency many steps can be made to enhance the way a building receives light in order to save money and energy. Today, America's schools spend more than $8 billion each year on energy and about 26 percent of electricity consumed by a typical school is for lighting alone.

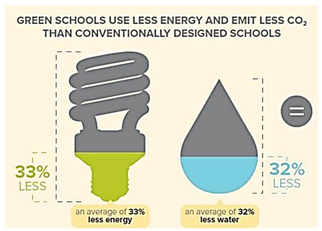


Objectives

- Design a school building in which 80% of the lighting is received passively
- Decrease the building's energy use by 33%
- On a long-term scale save the community and taxpayer's money
- Use the newly saved money for educational purposes

Significance

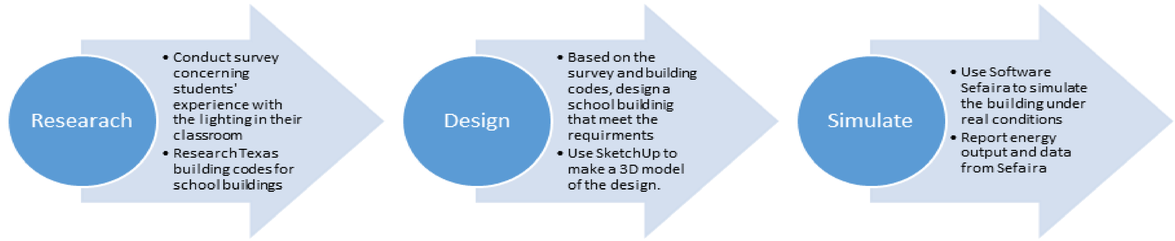
- Schools need to take advantage of sustainable and efficient construction methods
- Lighting affects student's focuses
- Lighting is responsible for a big amount of energy usage



Research Question

How can lighting in a school building be enhanced in a way that makes it sustainable economically, ecologically and socially while still being suitable for learning?

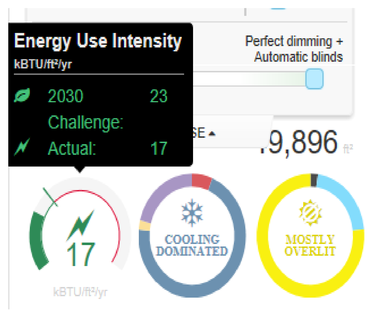
Methods and Tools

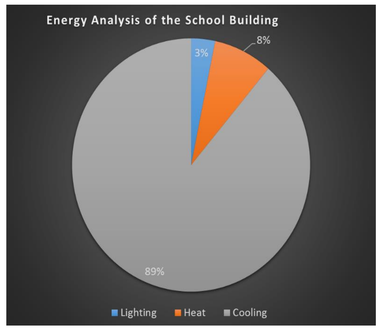


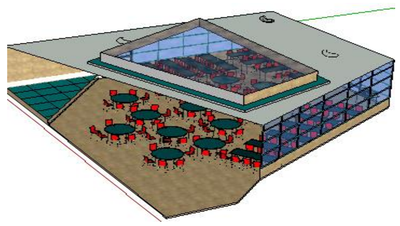
Results

- The results have shown that 85% of the students surveyed believe that classrooms are often too dim affecting their ability to focus
- 100% of the participants stated that they prefer brighter environment when studying
- 80% of the students stated that their teachers don't rely on passive methods of lighting, such as windows and skylights, and instead utilize light bulbs more
- The building without insulation in the walls and non-efficient use of HVAC consumed 36 kBTUs of energy
- After insulation and better HVAC systems were added, the total energy used by the school building reduced to 17kBTUs
- Of this 17kBTUs; 48,228 BTUs were heating, cooling was 536,301 BTUs, and only 19,617 BTUs were consumed due to lighting

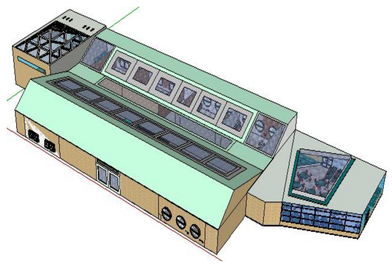
Type	Properties selected
WALL INSULATION	10.92 ft^2-h-°F/BTU Poor insulation
FLOOR INSULATION	4 ft^2-h-°F/BTU Poor insulation
ROOF INSULATION	9.16 ft^2-h-°F/BTU Poor insulation
GLAZING U-FACTOR	.36 BTU/ft^2-h-°F 2 Pane (low-e)
VISIBLE LIGHT TRANSMITTANCE	.67, 2 Pane
SOLAR HEAT GAIN COEFFICEINT	.21SHGC Reflective
HEATING EFFICENCY	4COP Heating pump efficient
COOLING EFFICENCY	3.99COP Efficient
INFILTRATION RATE	.39cfm/ft^2 Normal practice
VENTILATION RATE	.06cfm/ft^2 Typical ventilation
EQUIPMENT	.49w/ft^2 Good
LIGHTING	.48w/ft^2 Good
DAYLIGHT RESPONSE EFFICENCY	100% Perfect dimming + automatic blinds



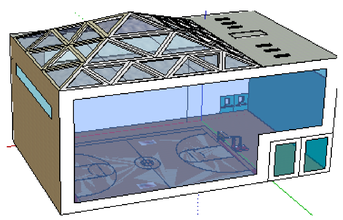




SketchUp model of the cafeteria



SketchUp model of the school building



SketchUp model of the Gymnasium

Discussion

Based on the simulation results, it is evident how changing the way a school building is illuminated can be sustainable. The passive methods along with energy efficient LEDs allowed for more natural lighting to brighten all the classrooms. Because of the unique design and structure of the windows, less energy was spent on lighting, which in return less was spent on heating and cooling. The energy consumption of the school building was significantly reduced, which helps the environment tremendously. Due to the less need for energy to keep the building functions running, there is a less need for the fossil fuels that produce this energy, releasing less of CO_2 in the atmosphere. In addition to this, the small energy usage of the school saves money through reduced utilities, making it economically sustainable as well.

Future Work

This study has shown how much lighting affects the footprint of a building and student learning behaviors. It can be inferred that if one were to focus on every detail, a dramatic change can be made in not only the way school buildings are designed, but also the affect they have economically, ecologically, and socially on the society. In future, the study can be extended through exposing students in the traditional vs. efficiently designed buildings and collecting data related to their learning behaviors.

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