Cost Effectiveness of Sustainable Building

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INTRODUCTION

Over the course of approximately two 50-minute classes, students will become familiar with the basic concepts of sustainable building. They will learn which changes can be made to a building for the smallest upfront cost and what reaps the largest long term benefits, financially and environmentally. The students will do this by beginning to design their own sustainable building on a tight budget.

LESSON OVERVIEW

Grade Level & Subject: 9-12: Social Studies, Science & Math

Length: Two 50-minute class periods.

Objectives:
After completing this lesson, students will be able to:

- Define sustainable building and understand its benefits
- Analyze the costs and benefits of certifying a school building as "green"
- Create a plan to certify a new school building as green

National Standards Addressed:
This lesson addresses the following National Education Standards[1]

Content Standard: NM-NUM.9-12.2 Compute Fluently and Make Reasonable Estimates
As a result of activities in grades 9-12, all students should:

- develop fluency in operations with real numbers, vectors, and matrices, using mental computation or paper-and-pencil calculations for simple cases and technology for more-complicated cases;
- judge the reasonableness of numerical computations and their results.

Content Standard: NS.9-12.6 Personal and Social Perspectives
As a result of activities in grades 9-12, all students should develop understanding of

- Personal and community health
- Population growth
- Natural resources

[1] Education World (2008) *U.S. National Education Standards*. Retrieved February 12, 2009, from http://www.education-world.com/standards/national/index.shtml.

- Environmental quality
- Natural and human-induced hazards
- Science and technology in local, national, and global challenges

Materials Needed:

- Computer and projector with internet access
- Chalkboard, whiteboard or equivalent
- Reproducible #1 - Plan of Action
- Reproducible #2 - Reflection Questions

Assessment: Students will be assessed through the following activities:

- Class/group participation: Students will begin designing a green school building in groups. Students must contribute equally to this. Students should also contribute to class-wide discussion of green building.
- Individual research: Every student must complete **Reproducible #1 – Plan of Action** demonstrating their individual research of a particular building aspect.
- Reflection questions: **Reproducible #2 – Reflection Questions** as homework will ask students to answer questions on their two days' work.

LESSON BACKGROUND

Information

Buildings, such as schools, use up 40% of our nation's energy and contribute more to global warming than anything else, including cars or agriculture. They use up 40% of our raw materials and account for 30% of our waste. Indoor air quality is usually much worse than outdoor air quality, and we spend 90% of our time indoors. In U.S. K-12 schools, half of the buildings have unsatisfactory indoor environmental conditions, and 60% of schools have major buildings disrepairs.

Fortunately, building green homes and commercial structures is becoming easier than ever. Ratings systems have been developed to certify green buildings, such as the LEED certification process. LEED uses a system of 69 points for regular buildings- 79 for schools- to evaluate and certify its sustainability level. Once a building has been certified green, it can be specified as LEED, LEED Silver, LEED Gold or LEED Platinum, which is the highest certification.

Green design takes ingenuity from people with all sorts of skills. Artists, mathematicians, scientists, engineers, architects, social scientists and others all have a role in green design, and every person and animal has a stake in sustainable living. Green buildings benefit us in the short and long term, and starting at a school is a great place to begin.

Relevant Vocabulary

Before beginning the exercises, make sure students understand the meaning of the following words. If not, define these words and make sure the students write them down. Some words that might come up are listed below.

- **Sustainability:** to meet the needs of the present without compromising the ability of future generations to meet their own needs.[2]
- **Greywater:** also known as **sullage**; Non-industrial wastewater generated from domestic processes such as dish washing, laundry and bathing.[3]
- **Efficiency:** The ratio of the effective or useful output to the total input in any system.[4]
- **Human-Made Climate Change:** Also known as **global warming;** The buildup of man-made gases in the atmosphere that trap the sun's heat, causing changes in weather patterns on a global scale.[5]

Additional Resources:

- U.S. Green Building Council. *LEED for Schools for New Construction & Major Renovations.* 2007 http://www.usgbc.org/ShowFile.aspx?DocumentID=2593
- Kats, Gregory. *Greening America's Schools: Costs and Benefits*. 2006 http://www.cap-e.com/ewebeditpro/items/O59F9819.pdf
- http://www.earthday.net/whygreenschools1/greenschoolsfactsheet.pdf
- United States Environmental Protection Agency. *Buildings and the Environment: A Statistical Summary*. 2004. http://www.epa.gov/greenbuilding/pubs/gbstats.pdf
- United States Environmental Protection Agency. *Global Warming and Our Changing Climate: Answers to Frequently Asked Questions.* 2000. http://yosemite.epa.gov/oar/globalwarming.nsf/UniqueKeyLookup/SHSU5BUN59/$File/gw_faq.pdf
- LEED Background Document, Earth Day Network, 2009.

LESSON STEPS

Before Class: *Getting Familiarized.*

1. Ensure that before class starts, students are already familiar with the most basic aspects of climate change, humans' effects on the environment, and the fact that buildings are arguably the worst offender.

2. If students need to do background reading, have them read either the Earth Day Network Background document or both EPA reports (above).

Class #1

Warm-up*: Pre-Assessment* (10-15 minutes)

1. Ask the students to say words that come to mind when they hear the terms "efficiency" and

[2] United Nations General Assembly *Report of the World Commission on Environment and Development: Our Common Future*. 1987. http://www.un-documents.net/wced-ocf.htm
[3] http://en.wikipedia.org/wiki/Greywater
[4] http://www.thefreedictionary.com/efficiency
[5] http://www.botany.uwc.ac.za/inforeep/glossary1.htm

"sustainability" and write these on the board. Answers may be broad, focused on the environment (eco-friendly, uses little energy), related to money (economic sustainability or efficiency), etc. All are acceptable, but ensure that students understand the broad definitions as well as their relation to the environment.

2. If there is time, ask if any students want to explain environmental concepts like global warming or green-building specific concepts like grey-water.

Activity 1: *Understanding a Green School and LEED* (20 minutes)

1. If there is access to a computer projector, pull up EDN's Green Schools Fact Sheet (http://www.cap-e.com/ewebeditpro/items/O59F9819.pdf) and familiarize students with reasons to make a school green. The three broad reasons are human health, environment, and long term finances. If there is no computer projector access, the first page can be printed and distributed to students. Additional lecture material can be pulled from Gregory Kats' report (above).
2. Pull up the USGBC's LEED for Schools document (http://www.usgbc.org/ShowFile.aspx?DocumentID=2593) and quickly familiarize students with the Leadership in Energy and Environmental Design certification and rating system. Emphasize the special categories meant for schools, such as mold protection. With no projector access, selected pages can be printed off and distributed to students.

Activity 2-A: *Designing a Green School* (10 minutes)

1. Give every student a copy of **Reproducible #1 – Plan of Action** and break them into groups of four or five. The students will be designing a hypothetical green building for the school, with a different student in charge of each LEED category. This material is dense and interdisciplinary, spanning math, science and social studies, so make sure that groups are diverse and that the students get along. The proposed situation:

   The school is designing a new building, with an operating budget of $160 per square foot. This is slightly larger than the national average and should allow for some green changes, but the school does not want to build a sustainable building out of fear that it will cost too much and be a hassle. Show that a green building can be financially advantageous by proposing green solutions that either cost a similar amount upfront, or that will save lots of money in the future. Be creative and come up with the cheapest, greenest building as possible, and make sure it is at least LEED certified.

2. Allow the students the remainder of class to decide amongst themselves who will lead on each task. If students are in groups of four, then one student can be assigned to each category: Design/Site Selection, Water/Energy Savings, Green Material Use, and Indoor Air Quality/HVAC. Let them know that their homework that night will be to fill out **Reproducible #1 – Plan of Action** with research on their sector assignment (i.e. Site Selection, Water/Energy, etc.) and some suggestions for moving ahead. They will meet in their groups for the majority of Class #2 to put their individual ideas together. Point them to EDN's LEED Background Document and all its sources for more information. If you'd like, tell the students that there will be a reward (extra credit or some sort of treat) for the group with the best plan.

Class #2

Activity 2-B: ***Designing a Green School*** (35-40 minutes)

1. Allow students to meet in their groups and share their ideas. The students will quickly put together a rough plan for a green building. Buildings sketches and precise monetary figures are not required, but are encouraged. Let students knows that this should be fun and that while their grade is affected by effort and participation, these concepts are new and difficult – creativity and not 100% proficiency is expected. The students should try to have enough information to give a mock proposal to a board of trustees or the school administration.
2. After 20 or 25 minutes, have students give quick (2-5 minutes, depending on class size) presentations of their green building. At the end, judge (or allow the students to vote on) the projects based on most money saved upfront and most money saved long term. Give a reward to the two best groups.

Wrap Up: ***Sharing Information*** (5-10 minutes)

1. Ask some students to share interesting information with the class. Look especially for students that were surprised by any information they learned. If any of the students have questions, see if their classmates can answer them based on their research. Pass out **Reproducible #2 – Reflection Questions** and ask them to fill out the open ended questions for homework.

Extension:
Based on the winning group's plan, and/or incorporating key elements from all groups, have the class put together a real proposal to present to the School Board, principal or district administrators. This time, realism and feasibility based on your actual existing school building should be stressed. It may also be advantageous to choose one, or just a few, element(s) to focus on (see EDN's Green Schools Student Action Plans for ideas). However, don't be afraid to make a bold proposition! If your class has data, research and economics on their side, anything is possible!

CONCLUSION

After completing this lesson, students will have a better idea of what makes a building green and will have applied these concepts in designing their own green building plan. Budget, health and design will be factors in their research and plans.

Plan of Action **Name:_____**

Sector:

Proposed Action*	Cost**	Savings***
_____ _____ _____ _____		
_____ _____ _____ _____		
_____ _____ _____ _____		
_____ _____ _____ _____		
_____ _____ _____ _____		

* A proposed action is a concrete step that will get at least one LEED point in that sector (site, energy/water, materials or indoor). With a new building, this will be a proposal that is not done in an average building

** The cost is the difference between the upfront cost of proposal and the standard alternative. As it will be difficult for an unfamiliar student to determine the exact monetary cost of a building's windows, percent may be used. For example, getting efficient windows may cost 10% more than getting the cheapest windows.

*** The long term savings of an action. Double glass windows will save as much as 30% of heating and cooling costs in an especially hot or cold month. [6]

[6] http://www.taunton.com/finehomebuilding/how-to/articles/understanding-energy-efficient-windows.aspx

Reflection Questions **Name:_____**

1. What do you think are the biggest benefits of green building: Health of the inhabitants? Saving the environment? Long term financial rewards? Something else entirely?

2. What, if any, are the biggest drawbacks to sustainable building? Do you think the drawbacks outweigh the benefits? Why or why not?

3. What was your favorite or least favorite aspect of designing a green building? If you were involved with sustainable construction or design in the future, what role do you see yourself having? Architect? Contractor/Framer? LEED consultant? Environmental lobbyist? Other?