SOCIETY OF ARCHITECTURAL HISTORIANS
SAH ARCHIPEDIA
ROTUNDA

TITLE: ARCHITECTURE AND THE ENVIRONMENT
SUBJECTS/TOPICS: ARCHITECTURE, GEOGRAPHY, HISTORY, SOCIAL STUDIES
GRADE LEVEL: K-2 (1 CLASS PERIOD)
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LESSON OVERVIEW

In this lesson we will explore how environmental factors influence design and building performance, what makes a piece of historic architecture "green," and how some contemporary architects are dedicated to creating sustainable structures that beneficially impact the natural environment and the experiences of their users.

BACKGROUND

There are many definitions of sustainable design. Instead of looking at advanced systems within the built environment, these lessons look at simple systems, such as the impacts of wind on buildings through the study of a familiar story, *The Three Little Pigs*. Students will also explore how materials are important to building design and performance.

The model building activity, and lesson extension that shifts the environmental force from wind to earth vibration, will require some supplies. Most are not consumables and they can be reused for different classes. For the models of the pigs' houses, you can use plastic straws, popsicle sticks, or uncooked spaghetti for the sticks, and building blocks such as LEGOs for the bricks since they can be interlocked. You will also need a mechanical fan to test the structures. If possible, no adhesives should be used: this will make the activity more about manual dexterity to tie, loop, and weave the straws or sticks together. You could introduce pieces of twine or string, if desired.

GUIDING QUESTIONS

How do environmental forces (i.e., sun, wind, and water) impact architectural design?

Why do we build with certain materials?

LEARNING OBJECTIVES

Cultivate visual observation skills by identifying different materials and building geometry within images of architecture.

Explore the use of different materials in architectural design and performance.

Develop architectural model building techniques.

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BACKGROUND, CONT.

For the student design challenge, use simple classroom materials that may already be available such as paper, building blocks, string, or even explore a "scavenge" exercise: what natural materials can students find in a recess area, such as leaves, small sticks, or even earth itself that mimics the use of rammed earth within some full-scale architectural projects. Given the use of different materials, adhesives such as tape or glue may be useful but it is suggested that you give each student or design team a designated amount.

Read the following sections on the SAH Archipedia webpage: History and FAQ.

These lessons are fundamental exercises in architecture and environmental systems, so the vocabulary is not too advanced. However, accelerated students may be curious to learn more. An Architecture and the Environment Vocabulary is attached for reference.

PREPARATION

One of the primary reasons why we create buildings is to escape natural elements, such as the sun, wind, and rain. Architects design buildings that are interesting and attractive, but some of the most important tasks for an architect is to design buildings that shelter us from the harsh sun, guard against the wind, and prevent rainwater from seeping inside. Can you think of other things that architects need to think about when they design?

CONTENT STANDARDS

Grade K:

Key Ideas and Details

- CCSS.ELA-Literacy.RI.K1
- CCSS.ELA-Literacy.RI.K2

Vocabulary Acquisition and Use

- CCSS.ELA-Literacy.K5.A
- CCSS.ELA-Literacy.K5.C
- CCSS.ELA-Literacy.K6

Presentation of Knowledge and Ideas

- CCSS.ELA-Literacy.SL.K.5
- CCSS.ELA-Literacy.SL.K.6

Grade 1:

Key Ideas and Details

- CCSS.ELA-Literacy.RI.1.1
- CCSS.ELA-Literacy.RI.1.2
- CCSS.ELA-Literacy.RI.1.3

Craft and Structure

- CCSS.ELA-Literacy.RI.1.4

Text Types and Purposes

- CCSS.ELA-Literacy.W.1.1
- CCSS.ELA-Literacy.W.1.2

Comprehension and Collaboration

- CCSS.ELA-Literacy.SL.1.2

Presentation of Knowledge and Ideas

- CCSS.ELA-Literacy.SL.1.5

Vocabulary Acquisition and Use

- CCSS.ELA-Literacy.L.1.6

Grade 2:

Key Ideas and Details

- CCSS.ELA-Literacy.RI.2.1
- CCSS.ELA-Literacy.RI.2.3

Integration of Knowledge and Ideas:

- CCSS.ELA-Literacy.RI.2.7
- CCSS.ELA-Literacy.RI.2.9

Research to Build and Present Knowledge

- CCSS.ELA-Literacy.W.2.7

Comprehension and Collaboration

- CCSS.ELA-Literacy.SL.2.2

Presentation of Knowledge and Ideas

- CCSS.ELA-Literacy.SL.2.5

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ACTIVITIES

Activity #1: The Three Little Pigs as a Design Lesson, Part I

- Your teacher will read a story aloud. Are you familiar with *The Three Little Pigs*?

- Let's talk about how each of the houses were built:
  - The first pig had a house of straw, piled together.
  - The second pig had a house of sticks that were stacked, and maybe some of the pieces were woven together to make the corners a little stronger.
  - The third pig, clearly the architect of the group, used bricks that were laid in careful rows then bonded together with something called mortar. This is like architectural glue, so the house was solid and strong.

- Use the images on the following worksheet to identify which little pig could have made the structure based on the building system: straw, sticks, or bricks.

- Now, write a number next to each structure with your guess on how it would perform against the wind forces from the Big Bad Wolf. Use #1 for the building that you think would be the strongest and most durable, then rank the others all the way to #9. This should be the building that you think would do the worst in the wind. Share your work with the class and explain your reasoning.

- Using the hyperlinks, explore the structures a bit further: are any of these located in places where, like the Three Little Pigs, the inhabitants have to worry about wind impacting the structure?

Activity #2: The Three Little Pigs as a Design Lesson, Part II

- Now it is your chance to see how the houses of the Three Little Pigs perform, in architectural models. Your teacher will provide the supplies to create small models of the house of straws, the house of sticks, and the house of bricks.

- Test each structure's resistance to the wind by using a fan.

- As we noted, the Three Little Pigs each used one material system. However, most building combine materials. Your teacher will provide materials and your challenge is to design and build a house for the Fourth Little Pig. Think about how the shape of your house and the materials you use can help resist the wind forces from the Wolf.

- Place all of the structures together and talk about the design feature: which ones do you think will be the strongest?

- Test the structures with the fan.

Lesson Extensions and Resources:

- If possible, try to find different illustrated versions of The Three Little Pigs in print or online. Examine the different ways the houses are represented. In most of the representations, the houses are all cubic structures: what would happen if we changed the shape? Would the materials perform differently if the building was in a different geometric form?Students might have a hard time picturing a brick wall with curvilinear forms:
    - Norman Village
    - University of Virginia Rotunda
    - The Huts
    - The Empress of Little Rock
    - Gammage Auditorium
    - Longwood (octagon)

- Outside of this folk tale, why do we not see too many buildings made of straw?
    - Explore SAH Archipedia buildings that use a roof system made of straw called thatch: Bus Stop and the Forebay Barn at Old World Wisconsin
    - Check out the William Maertz House that looks like it has thatch, but the roof is actually made of sturdier shingles.

- The Three Little Pigs primarily use one system for each of their houses. Why do most buildings use multiple materials?

- Try the Three Little Pigs building exercise but change the environmental force.
    - Instead of wind, think about ground movement: earthquakes. Have the students build examples of the straw, stick, and brick constructions, each on a piece of cardboard 1'x1'. Now use a small box (an upside-down board game box will work well) and place "earth" within the box. This can be marbles, sand, or small pebbles. Then place the reconstructed home on its cardboard base within the box; shake the box using lateral motions and see how the building performs. What happens when you change the composition of the "earth," mixing the different types vs. just using just one material?
    - Explore SAH Archipedia projects that were either impacted by earthquakes, or have some special earthquake resistant features:
        - Salt Lake City County Building
        - San Francisco City Hall
        - Capitol Records Tower

- Read Steven Guarnaccia's *The Three Little Pigs: An Architectural Tale* (2010)

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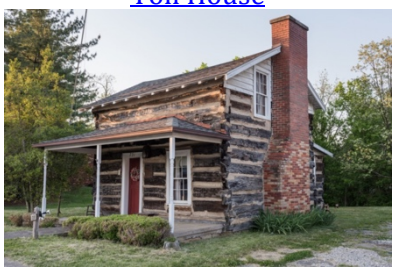
Identify the building system: straw (or earth), sticks, or bricks. The building might use a combination of systems, or you might need to make some guesses. Be prepared to explain the reason behind your answer.

Toll House



Building system:

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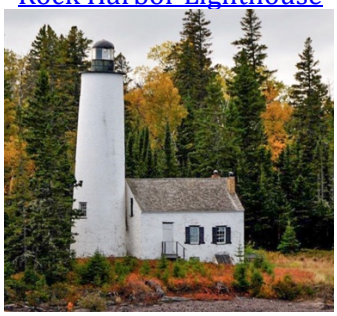
Rock Harbor Lighthouse



Building system:

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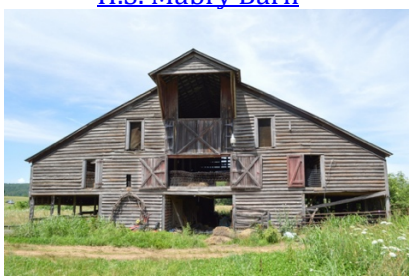
H.S. Mabry Barn



Building system:

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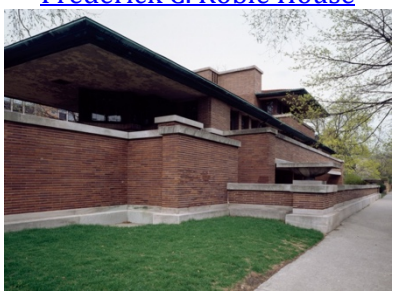
Frederick C. Robie House



Building system:

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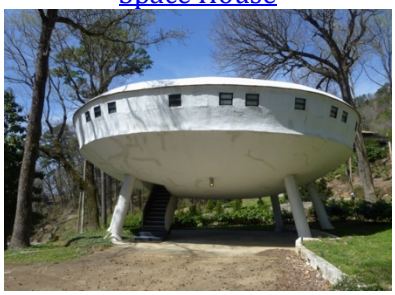
Space House



Building system:

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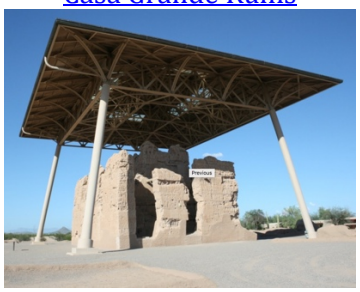
Casa Grande Ruins



Building system:

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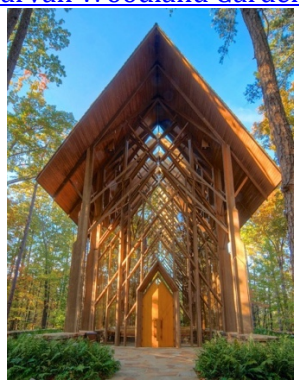
Garvan Woodland Gardens



Building system:

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Frontier Culture Museum

Building system:

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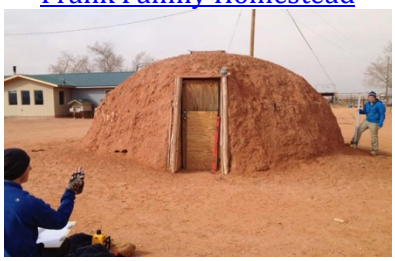
Frank Family Homestead



Building system:

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Architecture and the Environment Vocabulary

There are several important vocabulary words we need to understand in order to proceed with our lessons on sustainable design. Read the definitions below.

- **active environmental system:** any element or system of elements that function with moving parts and require regular user input. For example, a solar photovoltaic panel (PV) is an active solar device. The opposite of a passive system, but they often work together effectively.
- **adaptive reuse:** the conversion of a building, structure or area into a use other than that for which it was originally designed; this can often a 'green' practice since it saves existing structures and their associated embodied energy instead of completely demolishing a site
- **adobe:** thick earthen walls, effective thermal mass
- **apertures**: openings in a building, such as doors, windows, and skylights
- **brownfield:** a property that has or may have hazardous pollutants or contaminants; these need to be remediated (restore the soil, water, etc. to prevent further environmental damage) before redevelopment happens
- **building envelope:** the elements of a building that enclose conditioned spaces through which thermal energy may be transferred to or from the exterior or to or from unconditioned spaces. The major elements of the building envelop are the walls, windows and doors, the roof, and the floor or foundation.
- **cladding:** the exterior, protective and decorative layer of the building; this is separate from the structure
- **conditioned spaces:** the portions of a building that are mechanically heated or cooled; examples are rooms that have air conditioning
- **daylighting:** the use of the sun, instead of candles or electrical lighting, to illuminate interior spaces
- **ecology:** the interrelationships of living things to one another and to their environment, and the study of these interrelationships
- **embodied energy:** the amount of energy associated with extracting, processing, manufacturing, transporting and assembling building materials; a completed building has embodied energy
- **energy:** the potential to do work; power
- **energy flow:** the movement of potential/power from one part of a system to another
- **energy auditing:** the examination of the energy systems in a house as used by the current residents
- **energy ratings:** comparing existing houses to standard prototype residences
- **entropy:** the tendency for energy/matter to erode or become less organized over time in a system.
- **existing conditions:** the state of a site previous to the action of the designer. This includes all elements in the landscape and their arrangement. An existing conditions map, often call a base or index map, identifies and communicates these elements and often notes any particular challenges or opportunities. For design process purposes, it is essential that an architect fully study the existing conditions to understand key elements such as the environmental factors that may impact the site and the available, local material resources
- **feedback:** outputs of information, materials, or energy from a system. Positive feedback means that things are working well in the system; negative feedback means that one or more things need to be optimized in the system. Continually monitoring and management of feedback is important for getting the most beneficial and efficient results for a system.
- **glazing:** the use of glass in a building; to reduce solar gain and maintain indoor temperature balances, glass systems can be doubled, insulated and/or tinted
- **greywater:** water from bathroom sinks, showers, and any other non-kitchen and toilet fixtures. In terms of sustainable design practices, harvesting and reusing greywater can be a particularly valuable resource on a site.
- **infiltration:** accidental leakage of outside air into the building; major source of convective heat transfer through the building envelope

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- **insulation:** a material that helps maintain temperature consistencies (heating or cooling) for parts of a building
- **lifecycle analysis (or assessment):** tracking the environmental consequences and energy needs of material systems from resource extraction, through manufacturing and construction, to service-life performance, providing a powerful tool for measuring resource and energy efficiency
- **Life Cycle Cost Analysis (LCCA):** a method for assessing the total cost of facility ownership. It takes into account all costs of acquiring, owning, and disposing of a building or building system
- **microclimate:** a small-scale climate usually resulting from a variation in solar gain (exposure vs. shade), wind patterns (still vs. calm), water flows (still vs. moving), and/or human-derived heat sources.
- **passive environmental system:** any element or system of elements which function without moving parts or regular user input. For example, a south facing wall of glass is a passive solar device since it naturally adds heat to a space. The opposite of an active system, but they often work together effectively.
- **recycled material:** a remade or repurposed item that can be used for building construction
- **renewable:** usually referring to sources of energy or materials that are produced in relatively short timeframes; an element that can be harvested and then replaced, however the amount of time needed for renewal can be variable.
- **solar energy:** photovoltaic (PV) panels collect energy from the sun that can be harvested and distributed for use in building systems. For the maximum annual solar gain, the panels should be tiled to be perpendicular to the sun at its zenith. For optimal tilt, it is important to know the latitute to know the position of the sun; elements that can reduce the effectiveness of PVs are humidity, cloud cover, pollution, and shadows.
- **solar heating:** evacuated tube solar hot water heaters are vacuum glass cylinders filled with water, glycol, and a copper tube that collect heat from the sun and convert it into steam to generate hot water for bathing, kitchen use, or radiant floor system. They work with a closed flow loop and are very efficient since 92% of the thermal energy collected can be used within the system.
- **specific heat:** the heat holding capacity of a material or surface; water and stone can hold heat well, so they have a high specific heat.
- **stack effect:** the buoyancy of warm air
- **thermal mass:** heavy materials with the highest specific heat (ability to hold heat) such as stone, water, or earth that store incoming solar heat (during sunny hours) and then re-radiate the heat when there is little or no solar gain. It is important to get the most sun exposure, so in the northern hemisphere elements using thermal mass are usually found on the southern side of a structure. In the built environment, structures with thermal mass are particularly effective where temperature fluctuations are high, such as the desert.
- **ventilation:** the way air moves through the building; this can be with passive systems (i.e., open windows, cool air entering at a low level then hot air rising and escaping through high windows) or active systems (air conditioning or heating)
- **Venturi:** this is the effect when air or water increases speed through tunnel because of constriction. A Venturi can happen unintentionally in a building or natural condition, but it can also be a designed element in the built environment that effectively generates passive cooling.
- **Volatile Organic Compounds (VOC):** Off gasses from such products as carpet adhesive and paint usually that often cause allergic reactions or can aggravate asthma. Most green buildings employ low-VOC (or no VOC) products.
- **walkability**: a measure of how friendly an area is to walking
- **waste:** a misplaced resource; this is typically an unintentional and unwanted output of a system. Systems that are the most efficient, naturally, or the best designed are able to match inputs with their waste to create a closed loop, or at least one with minimal waste.
- **windbreak:** a natural, biological or built feature that deflects or slows the flow of air.

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