Design of a Green Roof

Grade Level:	Total Time Required:
4	4 periods (30 minutes each), approximate

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Lesson Objectives:

In this lesson, students will design and build a small model of a vegetated roof (green roof) for a house.

Students will be able to:

1. Understand how the plant responds to the green roof environment (reduced depth of soil and sloped surface).
2. Describe how the plant adapted to help them stay on the roof and live in the environment.
3. Observe how the green roof affects the surroundings that it lives in. (more green areas in urban and suburban regions).
4. Make appropriate measurements of distance (SI Units) and angles (depth of soil and roof angle).
5. Develop an engineered system to maintain the soil on the roof.
6. Gather evidence about how well the design meets the needs of the problem.
7. Document the design so that it can be easily replicated.

Indiana Standards:

4.LS.2 Use evidence to support the explanation that a change in the environment may result in a plant or animal will survive and reproduce, move to a new location, or die.

3-5.E. Identify a simple problem with the design of an object that reflects a need or a want. Include criteria for success and constraints on materials, time, or cost.

Next Generation Science Standards

3-5.ETS1-1 Identify a simple problem with the design of an object that reflects a need or a want. Include criteria for success and constraints on materials, time, or cost.

Science/Engineering Practices
1. Asking questions (for science) and defining problems (for engineering)
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence

Crosscutting Concepts
2. Cause and effect: Mechanism and explanation.

Common Core Mathematics:

4.MD.A.3 Apply the area and perimeter formulas for rectangles in real world and mathematical problems.

4.MD.C.6 Measure angles in whole-number degrees using a protractor. Sketch angles of specified measure.

Common Core English and Language Arts:

SL.4.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on *grade 4 topics and texts*, building on others' ideas and expressing their own clearly.

SL-4.1b Follow agreed-upon rules for discussions and carry out assigned roles.

SL.4.1c Pose and respond to specific questions to clarify or follow up on information, and make comments that contribute to the discussion and link to the remarks of others.

L.4.6 Acquire and use accurately grade-appropriate general academic and domain-specific words and phrases, including those that signal precise actions, emotions, or states of being (e.g., quizzed, whined, stammered) and that are basic to a particular topic (e.g., *wildlife, conservation,* and *endangered* when discussing animal preservation).

Concepts and Vocabulary

Term	*Defined by a scientist or engineer*	*Defined by a student*
Angle	The figure formed by two lines diverging from a common point.	Two lines that meet at a point.
Root	The usually underground portion of a plant that lacks buds, leaves, or nodes and serves as support, draws minerals and water from the surrounding soil, and sometimes stores food.	Base word, tree root
Accommodation	The act of accommodating or the state of being accommodated; adjustment.	Not in vocabulary
Adaption	- (Life Sciences & Allied Applications / Biology) Biology an inherited or acquired modification in organisms that makes them better suited to survive and reproduce in a particular environment.	Change in environment.
Height	The vertical distance from the bottom or lowest part of something to the top or apex.	How tall something is.
Erosion	The group of natural processes, including weathering, dissolution, abrasion, corrosion, and transportation, by which material is worn away from the earth's surface.	Landslide
Tropism	The turning or bending movement of an organism or a part toward or away from an external stimulus, such as light, heat, or gravity.	Not in Vocabulary
Angle of Repose	The maximum angle to the horizontal at which rocks, soil, etc., will remain without sliding.	Not in Vocabulary

Sources: 1) http://www.thefreedictionary.com

Equipment, Materials, and Tools

Materials		
1 large storage container with at least 4” high sides and 16” wide	Carry-out Meal Tray with Lid (Clear is best)	Pieces of cloth
Spoons	Small plastic cups (note size)	Straws
Modeling Clay	Duct tape	Zip ties
Corner beading	Lightweight foam	Craft sticks
Wire Pipe Cleaners	Card board	Velcro
Masking tape		

Tools		
Scissors		

Larger Trays
http://www.webstaurantstore.com/dart-c95pst1-9-x-9-1-2-x-3-clearseal-clear-hinged-lid-plastic-container-100-pack/999C95PST1.html?utm_source=Google&utm_medium=cpc&utm_campaign=GoogleShopping&gclid=CPnJwt7X57oCFeY-Mgod0F4AMQ

http://www.webstaurantstore.com/genpak-sn200-wht-9-1-4-x-9-1-4-x-3-white-large-1-compartment-foam-snap-it-hinged-lid-container-200-case/374SN200W.html
http://www.webstaurantstore.com/dart-solo-85ht1r-8-x-8-x-3-white-foam-square-take-out-container-with-perforated-hinged-lid-200-case/30185HT1R.html

Smaller Trays
http://www.bettymills.com/shop/product/view/Dart/DCCC25UT1.html?source=Froogle3&utm_source=Froogle3&utm_medium=cpc&utm_campaign=parts&utm_keyword=DCCC25UT1&utm_content=Food&gclid=CIqxs6DY57oCFaxDMgod7nUAeQ

Science Content - Basics

How do plants react to stimulus?

Plants may respond to directional and non-directional stimuli (a thing or event that evokes a specific reaction). Directional stimuli include gravity and sunlight while non-directional stimuli include changes in temperature and humidity.

A response to a directional stimulus is called a tropism. When plants are subjected to a stimulus, it results in differential cell growth in which cells on one side grow more than those on the other side. This causes parts of the plant to bend toward the side with less growth.

Common tropisms are phototropism in which plants bend towards a source of light and geotropism in which the plant determines the direction of gravity and allows the roots to grow downwards.

Benefits of plants to an ecosystem:

1. Plants use energy from the sun to convert carbon dioxide into oxygen and glucose and other sugars.
2. Provide food and shelter for organisms.
3. Provide ground cover to prevent soil erosion.

Source: [1]Life Science, A Closer Look, Teacher's Edition, Grade 4 MacMillan/Mcgraw Hill, 2011, Columbus, OH. ISBN: 978-0-02-287986-0

Plant physiology. (2017, January 4). In *Wikipedia, The Free Encyclopedia*. Retrieved February 1, 2017, from https://en.wikipedia.org/w/index.php?title=Plant_physiology&oldid=758347953.

Engineering Design

Synopsis of the Design Activity:

Problem:	A student whose aunt recently moved from the country to town. The aunt misses her garden and the only the place to start a garden is their roof. The girl wants help designing a green roof for her aunt to build.
Goal:	Design a green roof that supports soil at 45 degrees.
Who is the client:	A student whose aunt recently moved from the country to town.
End-User:	The Aunt
What is the design:	A roof slanted at 45 degrees without dirt moving down.
Criteria:	• The angle of the roof should be approximately 45 degrees.
Constraints:	• Maximum depth of soil (3 cm). • May only use the materials provided.

Lesson Plan #1
Guiding Question – How does the depth of soil affect root structure and height of plants?

Time: Four 30 minute class sessions

In this activity, students will learn how the depth of soil affects root structure and height of plants.

The teacher could ask, "Who has ever seen a tree growing on a hill? Does the tree grow straight up toward the sky, or does it grow out at an angle from the ground?"

Image from
http://rlv.zcache.co.uk/tree_on_a_steep_hill_wallclocks-rb140e02350954bf68b468f0646a67288_fup1y_8byvr_324.jpg

Image from
http://thumbs.dreamstime.com/x/tree-steep-hillside-8664828.jpg

Procedure:

Before conducting the experiment in the classroom, plant seeds in one tray with 2 cm of soil on both sides.

1. Obtain clear plastic drink cups, potting soil, and lettuce seeds sorted into three equal amounts (i.e,, approximately 20 to 30 seeds each).

2. Give students three cups and have them mark a line at 1 cm from the bottom on one cup, 2 cm from the bottom on the second, and 4 cm from the bottom on the third. Fill each cup with soil up to the marked line.

3. Give students seeds for each cup and have them spread the seeds across the top of each cup. Sprinkle a little soil across the top of the seeds.

4. Allow the seeds grow for about 2 weeks. Observe the root structure and height of the plants.

Figure 1. Plants in varying depth of soil

5. Have students draw a picture of a plant growing on the roof. Ask the students:
   What direction do the plants grow (i.e., what is the angle between the plant and the roof)?
   Are they tall plants (i.e., is growth limited due to root depth)?

6. Explain that plants adapt to their environment in many ways in response to an environmental stimulus (i.e., light, water, and gravity) which are called tropisms.
   Phototropism is a response to light (i.e., will move to follow the light source).
   Geotropism is a response to gravity (i.e., plant shoots will grow in opposite direction of gravity and roots will grow in the direction of gravity).
   Hydrotropism is a response to water (i.e., roots will grow in direction of water source).

7. Ask the students to predict what will happen to a plant in various areas of the roof (i.e., where there is less soil depth at the top of the roof and greater soil depth at the bottom of the roof).

8. Show the students the tray prepared earlier to show how the soil slid down the roof. Explain that this is the problem they are trying to solve so that they get uniform plant growth on the roof.

Lesson Plan #2
Guiding Question – Can you design a green roof?

Time: One 30 minute class session

Procedure:

1. Distribute the design challenge.

   Ask: *What is the goal?*
   Who is the user or client?
   What is the problem?
   What are the constraints?
   What materials will you use?

   Constraints:
   1. Height of soil must be less than or equal to three centimeters.
   2. The roof angle must be approximately 45 degrees.

2. Provide each team with a plastic (or Styrofoam) dinner tray. Have them measure the angle of the roof (i.e., when the tray is bent backwards) as shown in the figure below. Measure both sides. An extension activity is to sum the angles of the triangular roof which should equal 180 degrees.

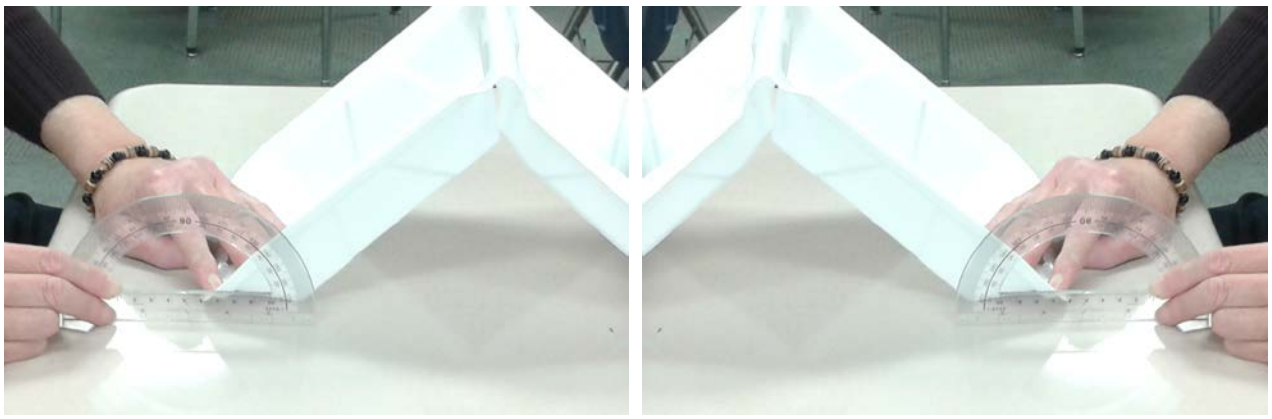


Figure 2: Measurement of tray angle.

3. Instruct students to develop his/her individual plan in his/her design notebooks. Encourage students to label their sketches, include dimensions, and list the materials they will use.

4. Instruct students to work in small teams to share their plans. Next, instruct students to decide on one plan or design and to select a representative from the team to share his/her plan to the teacher for his/her approval.

5. Once teams have teacher approval they may construct their design of their green roof. Remind the students that they should only build one side of their roof (i.e., the left or right tray) and leave the other side untouched to use as a control.

6. Add the same amount of soil to both sides of the roof.

Lesson Plan #4
Guiding Question – Testing your design.

Time: One 30 minute class session

Procedure:

1. Have students carefully stand up the tray at a 45 degree angle inside the large plastic tub.

2. Measure gap where the soil has moved away from top. Record the information in the table shown below.

	Gap at top of roof – Dry (mm)	Gap at top of roof – Wet (mm)
Original Roof (No Modifications)		
Modified Roof		

3. Add water (50 mL) to both sides of the tray.

4. Measure the gap where the soil has moved away from top a second time and record in the data table.

Assessment

The following are possible sources of formative and summative assessment:

- Design notebooks (individual) – Note how students identify and clearly label their drawings; Identify the types of science vocabulary students use in their notebooks (tally the number of times each concept is used); Note how students record data from testing their prototypes and how well they explain their results (patterns in the data).

- Presentation of design to class by the team. Provide positive design attributes, how design criteria where met, and possible redesigns.

- Participation (group) – Note level of engagement; questions students asked; how well they worked in a group; how well each team met the goals of the task.

- Other (individual and/or group) – Create a short pre and posttest that highlights key science vocabulary terms; Present a new situation or new problem on the same theme.

Lesson Extensions and Resources

Design Activity

Student Resource

Space for a Vegetable Garden

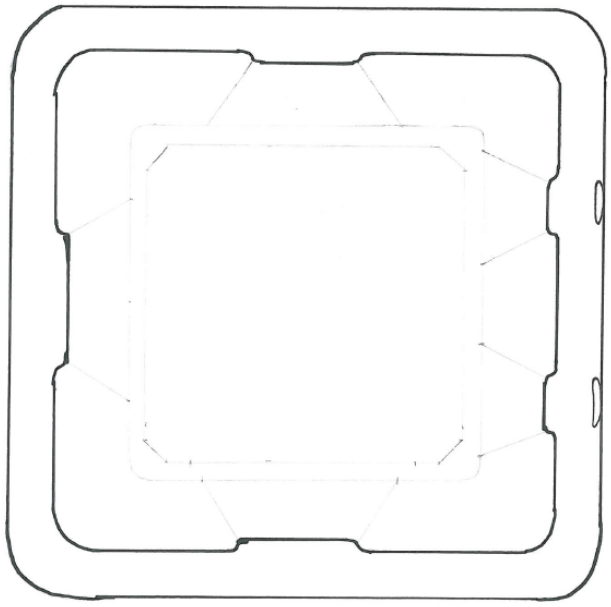
A fourth grade girl's Aunt has just moved to Lafayette, IN from a large farm. The girl's aunt is used to having a garden where she grows her own vegetables, but her new home does not have a yard where she can plant a garden. The girl and her parents went for a walk at Purdue University and saw plants growing on top of one of the buildings and learned that this is called a "green roof." The girl wants to help her aunt to plant a garden on her roof, and the girl learned that there are some engineering design constraints that are important for building the garden. She needs help designing a green roof that will allow her aunt to grow tall, healthy vegetables, so her aunt can build it. Can you help?

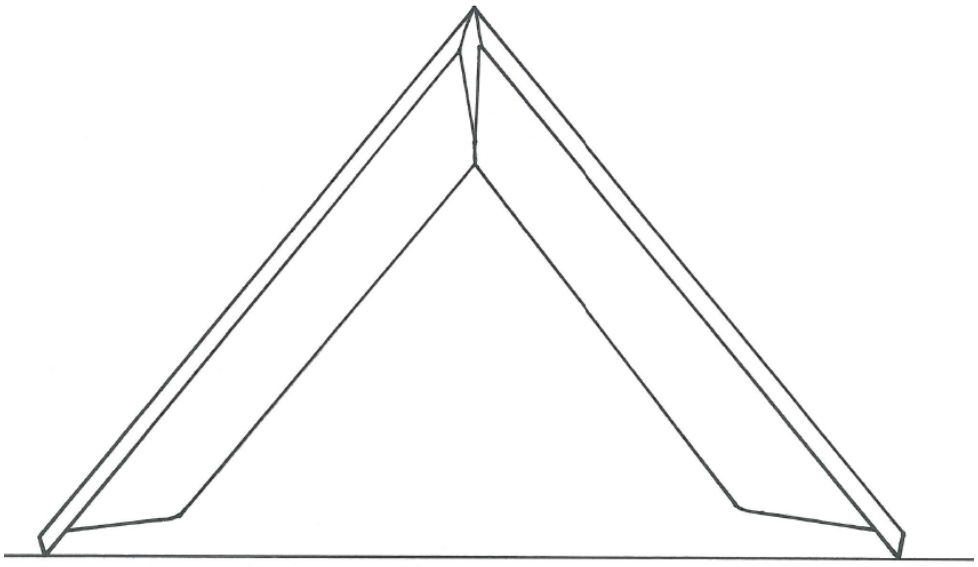
Criteria:

- The angle for the roof should be approximately 45 degrees.

Constraint:

- The depth of the soil on the roof must be less than 3 inches.
- You may only use the materials provided.





Examples of green roof designs