Roof Models

Note: This lesson plan was written for upper elementary-middle school grades. The lesson big idea, goals, and objectives are suitable for high school students. To adjust for high school, the instructor may:

- add to the diversity of supplies used to construct a roof model
- require mathematical estimation of water flow amounts with a rainfall of one inch,
- add different time frames for the rain event to increase the problem complexity (e.g., hypothesize erosion impacts with one inch of rain falling over a 12 hour period vs. a 6 hour period vs a 3 hour period, etc.)
- require roof model sketches before model construction, and
- require more than one type of roof model design and comparative tests of rainfall impacts.

Big Idea: We use models to explore the interaction of natural and designed (human) systems.

Learning Goal: Students design and test models to explore how water flows over roofs, on soil, and impermeable and permeable surfaces. Students explore the impacts of permeable and impermeable surfaces on surface water flow and erosion and design solutions to lessen these impacts.

Learning Objectives

Knowledge: Students understand that water moves differently over permeable and impermeable surfaces, that the angle of the roof affects the speed of water flow, and that models are used to test systems.

Skills: Students build models, observe and record data, and use descriptive language to explain observations.

Values: Students realize that humans (in this case, our buildings and associated infrastructure) affect the movement of water in a watershed and that humans can mitigate (lessen) erosion of soil and water movement with catchment systems (gutters, pipes, water storage tanks, etc.).

Grades: 4th-12th

Science Standards of Learning:

- 2010: 4.1, 4.9, 5.1, 6.1, 6.5, 6.7, 6.9
- 2018: 4.1, 4.8, 5.1, 6.1, 6.6, 6.8, 6.9
- High School Connections: Earth Science, Environmental Science, Career and Technical Education

Special Safety: Watch for water splashes on the floor and caution students to walk carefully on the wet surface.

Materials (per group of 2-4) NOTE: This list is not exhaustive. You can adjust materials to suit your learning goals:

- 1 Turkey roasting pan
- 1 Rectangular Cardboard "roof" in whole-inch dimensions (4" x 9" is a good size)
- Aluminum foil: 1-2 sheets
- Paper straws
- 2-4 Rubber bands
- 1 roll masking tape
- 2 Small plastic containers, or other stable objects for elevating model roofs (this will simulate the building)
- 1 Beaker (300 mL)
- Ground pepper in a pepper shaker
- Sponges (2 types, one that is very absorbent & one that is not, such as scotch brite), cut up in different sizes
- 1 Towel for clean up
- 1 Student datasheet

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Set-up:

1. Prepare rectangular cardboard roofs (use whole inches or centimeters for dimensions, then cover with a large piece of aluminum foil with lots of overlap). Alternatively, rectangles can be cut from plastic political signs. Then, the aluminum foil is not needed to cover the form. [*NOTE*: A utility knife makes cutting easy.]
2. Gather all supplies and distribute one set per group of 2 to 4 students.
3. Place tape, foil, rubber bands, and other extra supplies in an easily accessible location.

Instructional Strategy:

1. Activate prior knowledge & review key concepts prior to beginning each trial in the investigation.

Before Trial 1.

a. *Models*. We often use models to demonstrate/show how our world works. What is a model? Why do scientists and engineers often use models to help them understand how the world works?

b. *System*. (a) What is a system? [DEFINITION: A system is a collection of interrelated parts that work together to achieve one or more common purposes.] What makes up a system? [parts & a function; i.e., the system parts—or components- work together to produce an activity--the system process.]

(b) What are some examples of systems we might see in nature? Do humans make systems? Can you give some examples of human created systems?

(c) Is a roof a system? (If they are not certain then tell students they will build a roof model to help answer the question at the end of the investigation.)

c. *Water flow on a roof*. How do you think water moves over a roof? How can you describe this? (Ex. fast, slow, puddles/pools, slides off, pours off, etc.)

Before Trial 2.

a. *Roof Shapes*. Are all roofs the same shape? What are some other shapes, besides flat roofs, you have seen? [Ex. flat, angled, curved, etc.; steep slope, slight slope, etc.]

b. *Erosion*. Ask students to give examples and/or to provide a definition of erosion.

Before Trial 3.

a. *Erosion*. What happened to your "soil" when it rained on your roof? What do we call this process where water carries away particles of soil when water flows across the land? What impacts might erosion have on our watershed? [Ex. We lose soil that plants need to grow. The eroded soil clouds up the rivers, ponds, and lakes and can be harmful to the plants and animals that live in the water. It can make our water unsuitable for drinking, etc.]

b. Do you think it is OK to let water flow off a roof onto bare soil or is there a better way to manage rainwater flow? Discuss this question with the members of your group.

2. Roof model investigation trials

Trial 1. Explore. Model the flat roof set-up with your students with each group constructing a flat roof model. Instruct them to record their observations on their data sheets during the investigations. *Ask*: What do you predict will happen to the water when it "rains" on the roof?

a. Place a flat rectangle on top of two small plastic containers set (the "building) in a turkey roasting pan.

b. Pour water over the roof model. Ask students to observe and share their observations about what happened to the water that fell on the flat roof.

c. *Ask:* Can water soak into the roof? *No.* Why can't it soak through the roof? The word we use for this is impermeable (like waterproof, water cannot move through). *Language Arts tie-in*: How can we change the word to mean that water CAN move through? (~~Im~~Permeable)

Trial 2. Design and Test. Tell the student groups to design their own roof model, build them, and test how water flows on and off their roofs. *Ask*: What do you predict will happen to the water when it "rains" on your roof? Record your predictions in your datasheet.

a. Provide time for groups to explore pouring water over their roof model and make observations. Remind students to record observations on the data sheet.
b. If time permits, students may refine the design of their roof models and then, retest how water flows across and away from the roof. Ask: What improvements were made? How did these changes affect water flow?
c. *Explore erosion*. Give each group a pepper shaker which represents soil. Instruct them to sprinkle the soil at the base of their models and then, explore what happens to the "soil" when it rains on their roofs. Remind students to record observations on the data sheet.

Trial 3. Engineer to solve a problem.

a. Tell students that their next task is to design a solution to the water runoff and erosion problem they experienced in Trial 2.
b. Provide time for groups to consider and engineer a solution. Once they design a system, they test it, and record their results on their data sheets. [*NOTE*: Students will likely think of various catchment system designs and they may include rain gutters, pipes to move the water away from the base of their building, rain barrels or tanks to collect excess water, landscaping solutions to help absorb the water, etc. This is a time for your students to be innovative! Let them know that they can use any of the materials you provided such as the sponges, dixie cups, aluminum foil—can be shaped for various purposes.]
   Suggested questions to stimulate ideas, if needed:
   - What happens to the water once it is on the ground?
   - Do you have ideas for different ways for the water to flow off the roof to the ground?
   - How can we prevent water from running off the roof onto bare ground? How can we prevent erosion?
   - How can we capture the water that flows off the roof? Do we want to capture ALL of the water?

3. <u>Share their results</u>.

After all the tests and design refinements are completed (if time permits), conduct a gallery walk for students to see the variety of design solutions. Each group shares the components of their roof system designs, why they designed their system the way they did, and the results of their tests.

4. <u>Extending the investigation</u>.
   a. *Outdoor Investigation*. Take a walk around your school to examine the roof shape and relative (roughly estimated) roof size. Ask students to:
      i. Consider the amount of water that can flow off the roof, especially a heavy rainstorm.
      ii. Locate what systems the building has to alter how the rain falls off the roof.
      iii. Explore the type of surfaces that the roof water flows onto. *Ask*: Are these surfaces permeable or impermeable? What will happen when the water falls off the roof onto these surfaces?
      iv. Think of ways to improve the rainwater catchment system at their school.

Expand this inquiry by having students draw proposed design improvements to the school's system.

b. *Career Exploration*. Another wonderful extension to this investigation is to invite the school division Facilities Manager to talk with the students about how the school division manages rainwater runoff around the school buildings. Provide time for your students to ask questions based on their new understanding of rainfall from roofs, and storm water runoff and erosion.

NOTES

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Roof Models

	Draw or describe the roof and the surface the "building" model is on.	Predict: How will water move on the roof and to the ground? (Ex. fast/slow, in a line, spread out, soak in)	Assess: How did the water move? Did it match your prediction?	Observe: Describe the erosion that happened on the surface(s).
Sample Trial 1	**The roof is flat** **water falls on concrete**			
Trial 2				
Trial 3				

Engineer Names: _____

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Sample Trial 1	**Trial 1. Explore**	**Trial 1: All students use a flat top roof model to explore how water flows on and off the roof.** *Inquire to guide student investigations:* • What is a model? • What do you predict will happen to the water when you make it rain on your roof? • What does it mean to design something? • What is a system? What are the parts of our roof system?		
Trial 2	**Trial 2. Design & Test**	**Trial 2: A. Each student group designs, builds, and tests a roof model.** **B.** Students sprinkle ice tea crystals around their buildings to simulate soil & retest the impact of rain running from their roofs. *Inquire to guide student analysis:* • What type of angle is the roof on your building? • What happened to the water when you made it rain on your roof? • What happened to the "soil" when the water ran off your roof? • What do we call this process (of soil being removed by flowing water)?		
Trial 3	**Trial 3. Engineer to solve a problem**	**Trial 3: Students use the same roof model they used for Trial 2 and design a system to mitigate the impacts of water run-off from their roofs**. *Inquire to guide students' design process:* • What are some ways that we can change how the water moves across the roof surfaces? • What are some ways we can reduce erosion caused by the water running off the roofs? • What can we do to move water away from buildings and why do we do this?		

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