

# Erosion Engineering

## **Purpose:**

The purpose of this lesson is to introduce and describe types of erosion (water and wind). Students will identify examples of each type of erosion and observe how erosion changes the surface of the Earth. This lesson promotes STEM (Science, Technology, Engineering, and Mathematics) by integrating the Engineering Design Process into a cross-curricular lesson.

## **Lesson Goal or Objectives:**

Students will be able to design a method of protection for the Earth's land that would withstand water or wind erosion. They will gain an understanding of why engineers must be aware of the different types of erosion and what preventive measures they can take against erosion. This lesson will address the misconceptions that erosion is not a very serious environmental problem, we as humans have no control over the increasing rate of erosion on the earth, and that engineers work is not concerned with erosion.

## **Lesson STEM Challenge Question:**

What could engineer's design to protect the Earth's land (soil and sand) from water and wind erosion that will stop any destruction or significantly decrease the rate of destruction?

## **Target Group:**

This lesson is appropriate for students in third grade. The lesson can be modified for students in second and sixth grade to address the solid earth content expectations.

## **Estimated Time:**

Teacher Prep: 1 hour to gather materials, organize materials, create handouts

Student: 2 hours (1 hour over 2 days)

Day 1: Pre-Assessment, Engage, Explore, Explain

Day 2: Elaborate, Evaluate

## **Background Information:**

Erosion is the wearing away of the surface of the Earth by natural processes (weathering, dissolution, abrasion, corrosion, etc.). Water and wind erosion are continually changing the landscape of the Earth.

## **Water Erosion**

Water erosion is perhaps the most familiar type of erosion. Water erosion can lead to a variety of devastating effects. A layer of topsoil can be removed by raindrop splashes and run-off during storms. This can cause soil to lose nutrients, which affects the land's ability to produce crops. Run-off water may gather in flow lines (usually on recently cultivated land), leaving small channels along the soil and often deposits this soil in streams or reservoirs, which can damage the surrounding ecosystem. If this is not addressed, water will continue to deepen these channels into gullies, which results in the loss of significant amounts of land. Tunnels may form and the water in the tunnels will then remove soil below the Earth's surface. This causes cavities to form

underground, which weakens the surface. If these tunnels collapse, they become deep gullies. These tunnels are dangerous because these cavities could collapse at anytime and cannot be detected from above. Erosion along stream-banks is caused by moving streams or river water wearing away the surrounding banks. This can drastically change the course of a river and ultimately the surrounding landscape. Water erosion has also shaped canyons (e.g., the Grand Canyon in Arizona) and rock formations (e.g., Rainbow Bridge in Utah).

Engineers try and minimize erosion by directing the flow of water using dams and levees. Planting grass and trees (to form a strong root system) or laying out netting can also decrease water erosion. Mulch, a type of protective covering which is in direct contact with the ground, provides more protection than canopy cover. It can vary from straw, to compost, to wood chips, or saw dust. Spread evenly onto the ground, mulch helps to reduce water evaporation, control weeds, and enrich the soil. By absorbing the destructive forces of raindrops and wind, mulch reduces erosion until the seedlings mature enough to provide their own protective cover. Terracing is a combination of contouring and land shaping in which earth embankments, or ridges, are designed to intercept runoff water and channel it to a specific outlet. Terraces reduce erosion by decreasing the steepness and length of the hillside slope and by preventing damage done by surface runoff.

### **Wind Erosion**

Wind erosion creates and moves entire sand dunes, shapes rocks and other structures, and causes dust storms. Sand dunes are always being reshaped and shifting due to the wind. Dunes start out as mere ripples in the sand and gradually increase in size. Sand is moved up to the top of the dune until the pile becomes so steep that it collapses and slumps down the other side (the slip face). Sand dunes are particularly vulnerable to wind erosion because they are completely composed of loose sand without anything anchoring them in place. Wind erosion also shapes rocks and deteriorates structures, such as the ancient pyramids in Egypt. The wind picks up grainy particles such as sand and literally becomes airborne sandpaper that wears away (sands down) surrounding surfaces. The famed Devil's Tower in Wyoming (our nation's first national monument; see Figure 6) was actually created by wind erosion. It used to be a volcano, but now all that remains is the solidified, lava core. (The wind was powerful enough to cut away an entire volcano.)

Engineers have identified the most effective way for preventing wind erosion. They suggest locating livestock watering facilities on non-erodible soil. They protect agricultural fields and heavy-use areas with shelter belts, which are barriers of trees and shrubs planted in one or more rows at right angles to the direction of the wind. Maintaining a good balance between herbaceous and wood plants along with spacing shrubs and trees strategically will reduce wind erosion.

### **Vocabulary/Definitions**

**Deposition:** The act or process by which an agent of erosion such as wind or water lays down matter (sediment).

**Erosion:** The wearing away of the surface of the Earth by natural processes (weathering, dissolution, abrasion, corrosion, etc.); types of erosion include: chemical, water, wind, glacier and temperature.

**Geology:** The scientific study of the origin, history and structure of the Earth.

**Sediment:** Material that settles to the bottom of a liquid.

**Slip Face:** The side of a sand dune on which sand collapses once the dune slope becomes too steep to support any more build up of sand.

**Weathering:** Gradual physical and chemical wearing away of rocks.

Mann, C. C. (2008, September). *Our Good Earth* [Electronic version]. National Geographic, 1-9.

United States Department of Agriculture, Natural Resource Conservation Service, Erosion. Retrieved March 10, 2013, from [http://www.ctenvirothon.org/studyguides/soil\\_docs/wind\\_water\\_erosion\\_pics.pdf](http://www.ctenvirothon.org/studyguides/soil_docs/wind_water_erosion_pics.pdf)

Pidwirny, M. (2008). Soil erosion and deposistion. In S. Draggan (Ed.), *The Encyclopedia of Earth*. Retrieved February 2, 2013, from <http://www.eoearth.org>

### **Grade Level Content Expectations**

#### **Inquiry Process:**

**S.IP.03.11** Make purposeful observation of the natural world using the appropriate senses.

#### **Inquiry Analysis and Communication:**

**S.IA.03.14** Develop research strategies and skills for information gathering and problem solving.

#### **Reflection and Social Implications:**

**S.RS.03.17** Identify current problems that may be solved through the use of technology.

#### **Content Expectation:**

**E.SE.03.22** Identify and describe natural causes of change in the Earth's surface (erosion, glaciers, volcanoes, landslides, and earthquakes).

### **Materials:**

Note: For a class of approx. 30 students, have students in 6 groups of 5 students per group and create THREE of each station (e.g. three water erosion stations, three wind erosion stations) within the classroom. This will ensure that the centers are not overcrowded.

#### **Water Erosion Station (x 2)**

- Large container (e.g., a deep plastic bin at least 18 inches x 9 inches)
- 8 cups Moist soil
- 12 coins or poker chips
- 1 roll of Paper towel
- Watering can (one with several holes in the spout)
- Water (approx. 24 oz)
- Ruler
- List of Procedures for this station

#### **Wind Erosion Station (x 2)**

- 8 cups of Sand
- Small-size motorized fan (handheld if possible)
- Large bin (e.g., a deep plastic bin at least 18 inches x 9 inches)
- List of Procedures for this station

#### **Engineering Materials**

- One large bin of herbaceous plants, trees, shrubs (can be artificial)

- 50 6 x6 sheets of cage wire fencing
- 50 6 x 6 sheets of erosion matting (burlap material)
- One large container of straw (20 cups)
- One large container of mulch (20 cups)

Handouts: (one per student)

- Copy of the Erosion Worksheet
- Copy of the pre-assessment Now and Later Worksheet
- Copy of the STEM Booklet
- Copy of the Erosion Mathematics Worksheet
- Copy of the post-assessment Poster Rubric
- 30 sheets of white 11 x 14 paper
- Pre-made sticky name tags that say "Erosion Engineer"

### **Lesson References:**

Ellis, T., Schaefer, M., & Yowell, J. (2012, September 20). The Earth is a Changin'. In TEACH Engineering. Retrieved March 14, 2013, from [http://www.teachengineering.org/view\\_lesson.php?url=collection/cub\\_/lessons/cub\\_earth/cub\\_earth\\_lesson5.xml](http://www.teachengineering.org/view_lesson.php?url=collection/cub_/lessons/cub_earth/cub_earth_lesson5.xml)

Ellis, T., Schaefer, M., & Yowell, J. (2012, September 20). Glaciers, Water and Wind, Oh My!. In TEACH Engineering. Retrieved March 16, 2013, from [http://www.teachengineering.org/view\\_activity.php?url=collection/cub\\_/activities/cub\\_earth/cub\\_earth\\_lesson5\\_activity1.xml](http://www.teachengineering.org/view_activity.php?url=collection/cub_/activities/cub_earth/cub_earth_lesson5_activity1.xml)

Mann, C. C. (2008, September). Our Good Earth [Electronic version]. National Geographic, 1-9.

United States Department of Agriculture, Natural Resource Conservation Service, Erosion. Retrieved March 10, 2013, from [http://www.ctenvirothon.org/studyguides/soil\\_docs/wind\\_water\\_erosion\\_pics.pdf](http://www.ctenvirothon.org/studyguides/soil_docs/wind_water_erosion_pics.pdf)

Pidwirny, M. (2008). Soil erosion and deposition. In S. Draggan (Ed.), The Encyclopedia of Earth. Retrieved February 2, 2013, from <http://www.eoearth.org>

### **Safety Considerations:**

Ensure that all students are aware that it very dangerous to drink or get any of the water/soil mixture near their eyes and mouths. Also, when using a fan to blow sand, students must be sure that sand is staying away from their eyes (protective eyewear can be worn if the teacher finds it necessary).

## STEM Lesson

**Note:** This lesson would be best to teach right after lunch. When the students exit the classroom the teacher should set-up the 6 stations within the classroom by grouping together the students desk (if the room is not set-up this way already). When the students get back from lunch, the teacher can jump right into the lesson.

### Engage and Pre-assessment:

Have the students watch the following video from Discovery Education:

Title: Erosion

Length: 7 minutes 30 seconds

(2005, January). In Discovery Education Erosion Video. Retrieved March 10, 2013, from <http://app.discoveryeducation.com/search?Ntt=water+erosion>

**State:** Today we are going to learn and understand what erosion is and about two different kinds of erosion that occur on Earth. The EXCITING part is that all of you are going to become engineers during this lesson! An engineer is someone who designs, builds, and/or maintains something (give them real life examples). Today all of you will be "Erosion Engineers" working for a company that is developing techniques and structures to protect the land from erosion. In doing this we will be making a difference and protecting our environment here on Earth.

Note: Pass out pre-made sticky name tags that say "Erosion Engineer" on them. Allow the students to write their name below this title if they would like.

Before they begin their work as Erosion Engineers, find out what they already know about erosion. Handout the Now and Later worksheet to each student and have them work independently on it. When the students have completed it, the teacher will review the student responses to identify what prior knowledge the students have on erosion. At this point the teacher will modify the lesson if necessary.

NOW

and

LATER

True or False: Erosion can wear away the surface of the Earth by chemicals, wind, water, glaciers and temperature (Answer: True)	True or False: Erosion can wear away the surface of the Earth by chemicals, wind, water, glaciers and temperature (Answer: True)
True or False: Chemical erosion is a reaction that usually involves water that has been polluted by chemicals, such as acid rain. (Answer: True)	True or False: Chemical erosion is a reaction that usually involves water that has been polluted by chemicals, such as acid rain. (Answer: True)

True or False: Erosion can wear away the surface of the Earth by chemicals, wind, water, glaciers and temperature (Answer: True)	True or False: Erosion can wear away the surface of the Earth by chemicals, wind, water, glaciers and temperature (Answer: True)
True or False: Wind erosion is rivers, streams or even rain, breaking away at bits of land while moving over it. (Answer: False, water erosion is described here.)	True or False: Wind erosion is rivers, streams or even rain, breaking away at bits of land while moving over it. (Answer: False, water erosion is described here.)
True or False: Wind erosion can create and move entire sand dunes, shape rocks and other structures and cause dust storms. (Answer: True)	True or False: Wind erosion can create and move entire sand dunes, shape rocks and other structures and cause dust storms. (Answer: True)
True or False: Engineers do not need to know about erosion. (Answer: False, engineers use knowledge of erosion for many different applications, including the safe design and building of structures, highways, sidewalks and also for the protection of natural monuments.)	True or False: Engineers do not need to know about erosion. (Answer: False, engineers use knowledge of erosion for many different applications, including the safe design and building of structures, highways, sidewalks and also for the protection of natural monuments.)
True or False: Engineers also learn about erosion to help protect existing land formations and monuments that people want to keep around. (Answer: True)	True or False: Engineers also learn about erosion to help protect existing land formations and monuments that people want to keep around. (Answer: True)
True or False: Water erosion causes sand, acting as sandpaper, to wear away surfaces as it moves over something. (Answer: False, wind erosion is described here.)	True or False: Water erosion causes sand, acting as sandpaper, to wear away surfaces as it moves over something. (Answer: False, wind erosion is described here.)

**Explore:**

**Challenge:**

Create erosion (wind or water) within your container that is destructive to the land (sand or soil).

**Constraints:**

You must use ALL of the materials provided at your station.

You must use only the materials provided at your station.

You must start with a sand or soil pile in your container that is 6 inches tall.

Each group member must participate in the design, construction, and carrying out of the erosion.

**Build:**

Allow the students time to create erosion in their container. If students needs scaffolding here are the procedures that would yield erosion destruction:

**Water Erosion Station Procedures:**

1. In a large container, form a mountain of soil about 3 inches across (wide at the top) and about 5 or 6 inches tall in the container.
2. Press the coins/chips into the surface of the dirt/clay. (Place them at different angles with the edge protruding out; leave about half the coin showing.)
3. Create a rainstorm by pouring water on the mountain with the watering can.
4. Remove the coins and put them back onto a paper towel to dry.
5. Drain the water into a sink. Allow them to make meaningful observations by looking, touching, feeling, and smelling.

**Wind Erosion Station Procedures:**

1. Form a pile of sand in the center of the box (approximately 5 or 6 inches tall).
2. Using the fan, blow air lightly over the sand from one end of the box to the other.

**Teaching Points (ask them):** What kind of materials do you see? How do these materials relate to the Earth? What happened when you created erosion at your station? How might these stations relate to erosion (the wearing away of the surface of the Earth)? At this time engage the class in a group sharing session, so that the groups who were at the water erosion station can see what happened at the wind erosion station and vis versa. Allow the students time to record what their observations as well as their classmates observations on the Erosion Worksheet for the station opposite of what they are at. (This will show students how they can collaborate together as a team.) Observations may include: did the pile of sand move? are the coins sticking out more or less? what does the bottom of the mountain look like? Allow them to make meaningful observations by looking, touching, feeling, and smelling.

**Explain:**

Read the book *Erosion*, written by Becky Olien. This book provides great pictures and information on water and wind erosion. During the reading, use stopping points to ask the students questions to get them engaged and check the their comprehension. At this point clarify how engineers play an important role in erosion; by creating protective structures for the land. Encourage students to generate ideas for possible structures.

**Questions to use:**

What purpose would a protective structure serve against erosion? (eliminate or reduce the devastating affects of erosion)

What materials do you think engineers may use when protecting the Earth's surface from erosion? (answers may vary)

In our community can we see any signs of erosion or protective structures that have been put in place by engineers to eliminate or reduce the damage erosion can cause?

**Elaboarate:**

Give the students the scenario: The company Erosion Engineers has hired all of you to help them create methods of protection for the land against wind and water erosion.

**Challenge:**

Present students with the challenge: Design a method of protection for the land in your "container" (sand or soil) from the type of erosion that your group finds at your station (wind or water), that will significantly reduce the negative effects of the erosion.

**Constraints:**

You must use at least one of the engineering materials provided (5 provided by teacher; list found in materials).

You may not use any other outside materials to create the protection.

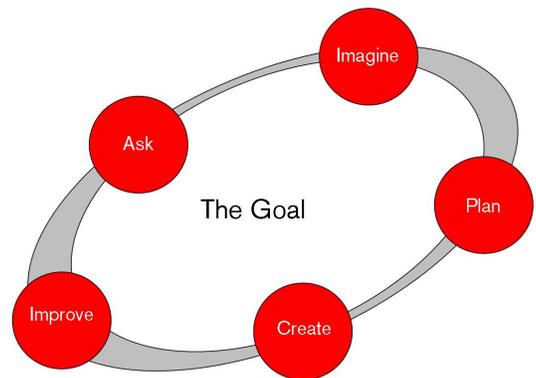
You must start with a sand or soil pile that is 6 inches tall.

You must use the same amount of water/wind force when testing your method of protection, that you initially used to create the erosion.

Each group member must participate in the design, construction, and testing of the protective structure.

**Note:**

Before building roller coasters, introduce the Engineering Design Process to students. Explain that the Engineering Design Process is a step-by-step process that engineers and designers use to solve problems. The Engineering Design Process is cyclical and can begin at any step, or move back and forth between steps numerous times. In real life, engineers often work on just one or two steps and then pass along their work to another team.



Distribute the Design Process (STEM) Booklet to students as a guide. Students will complete the booklet as they work through the process as a group. The teacher should encourage students to "check-in" after they have developed and drawn their plans before they proceed to create their design. This will help manage materials and potential issues that may result with a too complicated or too simple design.

**The Engineering Design Process (STEM) Booklet:**

**ASK**

What is the problem?

What have others done?

What are the constraints?

**IMAGINE**

What are some solutions?

Brainstorm ideas.

Choose the best one. Why?

**PLAN**

Draw a diagram.

Make lists of materials you will need.

**CREATE**

Follow your plan and create it.

Test it out!

### **IMPROVE**

Talk about what works, what doesn't, and what could work better.

Modify your design to make it better.

Test it out!

\*encourage students to continue to make modifications because the engineering design process can be used again and again (continuous circle).

### **REFLECTIONS**

Final thoughts on design and the modifications made.

### **Student Collaboration:**

Have each group of Erosion Engineers explain and show their design to the class. Have them describe the process they took, any modifications they made, and the challenges they faced along the way. Ask the groups if they had more time would they have done anything differently and would they have changed any of the constraints that were put in place.

### **Evaluate:**

#### **Post Activity (Mathematics):**

Have students complete the Erosion Math Worksheet to support the erosion lesson they just completed. The worksheet will provide them with erosion story problems, allowing them to compute the damage erosion has caused. They will make the connection of how these effects could have been eliminated or reduced from the designs they themselves just constructed.

#### **Post Activity:**

Have students complete the Now and Later Worksheet from the beginning of the lesson. Discuss and allow the students to keep this worksheet.

#### **Post-Assessment and Real-World Connection:**

Pass out the Erosion Project Rubric to the students. Make sure that they understand what is required of them and the due date (a week is suggested for them to complete it). This project offers students two choices:

Choice 1: This will require students to become erosion detectives as they research and observe in their community for signs of erosion. This will allow them to make a real-world connection with erosion. A brief letter should be sent home to parents for this assignment, so that the parents can assist their child outdoors. They will make a poster on a 11 x 14 sheet of paper; half of it will be a drawing of what they found and the other half will be a short paragraph explaining what is happening in their photo, how it represents erosion, and what they could construct to reduce the negative effects of the erosion.

Choice 2: This will require students to become erosion detectives as they research online, in magazines, newspapers, or books for real life examples of erosion. This will allow them to make a real-world connection with erosion. A brief letter should be sent home to parents for this assignment, so that the parents can assist their child with the research. They will make a poster on a 11 x 14 sheet of paper; half of it will be a drawing of what type of erosion occurred in the

real life example they found and the other half will be a short paragraph explaining what type of erosion occurred, where it occurred, what the most devastating affects were, and what the community did afterwards (if nothing, what could they have done).

### Erosion Poster Project Rubric



Requirements	Possible Points
Illustration is neatly drawn	2 points
Illustration is creative and colorful	3 points
Illustration depicts erosion	5 points
Paragraph is at least 5 sentences	3 points
Paragraph has no spelling or grammar errors	2 points

Requirements	Possible Points
Paragraph explains the illustration drawn and relates it to erosion	5 points

## Erosion Worksheet

### Instructions

Answer the following questions as you experiment with each different erosion stations.

### *Station 1: Water Erosion Station*

1. What caused the clay/dirt to run off the mountain?

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2. Are the coins sticking out more or less? Why?

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3. What does the bottom of the mountain look like?

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4. What are some other examples of water erosion?

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### *Station 2: Wind Erosion Station*

1. What happened to the sand as the fan blew on it?

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2. Could you make the whole pile of sand move if the fan blew long enough?



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3. How could you keep a sand dune from moving?

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4. What are some other examples of wind erosion in nature?

## Erosion Math Worksheet

1. If a 12-acre forest lost  $\frac{1}{4}$  of its trees due to acid rain, how many acres would be undamaged?

2. If property damage due to erosion along the coast is \$60 million each year, how much money would be spent in 4 years?

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3. Your favorite beach has 42 large sand dunes. Throughout the course of the year, wind erosion destroys 8 sand dunes and creates 13 new ones. How many sand dunes would there be at the end of the year?

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