EDUCATOR GUIDE

FORCES OF NATURE

This guide introduces concepts and activities for educators to use with their students centered around the *Forces of Nature* gallery at Arizona Science Center. This guide contains activities that are aligned to state standards and are organized by grade band.

ARIZONA SCIENCE CENTER

Never stop wondering.
Never stop imagining.™

EXHIBITS OVERVIEW AND CONCEPTS

CLOUD SPINNER
Use a spin-browser to change the speed and direction of videos that show cloud formation and movement.
Concepts: *Meteorology, Air Pressure, Condensation*

GRAND CANYON
Guests can use a topographical map to analyze different faces of the Canyon, as well as its weather, history and more!
Concepts: *Geology, Hydrology, Erosion*

IMMERSION THEATER
The focal point of *Forces of Nature* is our extreme weather simulator! Step inside and experience the heat of a volcano or the torrential rain of a hurricane.
Concepts: *Weather, Volcanology, Plate Tectonics*

MAKE A VORTEX
A specially-constructed table produces thick clouds of "fog" that form into swirling vortex rings by the Guest.
Concepts: *Vortices, Meteorology*

MAKE WAVES WITH WIND
Guests use an overhead fan's changing speed to influence the height and spread of water waves in a glass bowl.
Concepts: *Waves, Oceanography*

PLATES ON THE MOVE
A shaky table is used as a surface to build sturdy structures with Keva planks. See whose structure stands up to "earthquakes" the best!
Concepts: *Plate Tectonics, Structural Integrity*

ROCK RECYCLER
Look into a virtual world to see robots change one type of rock into one of the other two types! Use a flowchart to predict how your rock will end up.
Concepts: *Rock Cycle, Geology*

RIFT ZONE
Gaze down into a basin filled with fine silica sand, and watch as the changing pressure underneath creates rifts similar to those found on Earth's surface.
Concepts: *Geology, Plate Tectonics*

SEE THE HEAT
A heating rod, suspended in room-temperature water, turns on and causes visible movement as the warmed liquid rises to the surface.
Concepts: *Plate Convection Cycles, Fluid Dynamics*

SCULPT WITH WIND
Guests use a side-blowing fan to create elegant formations in blowing sand.
Concepts: *Plate Erosion, Deposition*

SRP FACES OF SCIENCE KIOSKS

Three display cases showcase individual scientists (geologist, meteorologist, hydrologist) along with examples of their work and tools.
Concepts: *Plate Science Fieldwork*

SRP WATER ENERGY CENTER

This workstation presents tabletop activities that excite and engage Guests as they explore hydrology and water conservation phenomena. It also features Team Member-led interactives at various times.
Concepts: *Plate Water Conservation, Dams, Hydrology*

TAKE A CLOSER LOOK

Use mounted magnifying glasses to inspect 18 samples of all three types of rock: igneous, sedimentary and metamorphic. Notice the huge differences between rocks of the same type!
Concepts: *Rock Cycle, Geology*

TECTONIC BASIN

Watch shaking sand flow! Look inside the basin and watch the sand shift and flow into ever-changing patterns of ripples and dunes.
Concepts: *Geology, Plate Tectonics*

WILD WIND STORM SIMULATION

Try to survive the wild wind of a hurricane!
Concepts: *Weather, Wind, Natural Disasters*

CARBON EXCHANGE

See how carbon is always on the move between the air, water, land and living creatures.
Concepts: *Volcanology, Erosion, Fossil Fuels*

ROIL AND BOIL

Take a look inside the layers of our restless inner earth!
Concepts: *Layers of the Earth, Human Impact, Volcanology*

ESSENTIAL QUESTIONS

These four questions provide the framework for guiding learning through *Forces of Nature*:

1. What is air made of? What causes trees to move and waves to form on ponds?
2. When considering natural disasters such as hurricanes, tornadoes and earthquakes, what role does friction play?
3. How do forces inside the earth take a sandstone and form lava?
4. Consider a flowing stream. What forces are involved with erosion?

EDUCATOR RESOURCES ALIGNED TO EXHIBIT STANDARDS

EROSION

EARTH'S LAYERS

PLATE TECTONICS

ATMOSPHERE

WEATHER

THE ROCK CYCLE

HISTORY OF WATER USE IN PHOENIX

NASA RESOURCES ON SEASONS, ATMOSPHERE, SOLAR SYSTEM, AND SPACE

EXHIBIT STANDARDS BY GRADE LEVEL
2018 ARIZONA SCIENCE STANDARDS

KINDERGARTEN
K.E1U1.3 Observe, record, and ask questions about temperature, precipitation, and other weather data to identify patterns or changes in local weather

K.E1U1.4 Observe, describe, ask questions, and predict seasonal weather patterns; and how those patterns impact plants and animals (including humans).

GRADE 2
2.E1U1.4 Observe and investigate how wind and water change the shape of the land resulting in a variety of landforms.

2.E1U2.6 Analyze patterns in weather conditions of various regions of the world and design, test, and refine solutions to protect humans from severe weather conditions.

2.E1U3.7 Construct an argument from evidence regarding positive and negative changes in water and land systems that impact humans and the environment.

GRADE 4
4.E1U1.5 Use models to explain seismic waves and their effect on the Earth.

4.E1U1.7 Develop and/or revise a model using various rock types, fossil location, and landforms to show evidence that Earth's surface has changed over time.

4.E1U1.8 Collect, analyze, and interpret data to explain weather and climate patterns.

4.E1U2.10 Define problem(s) and design solution(s) to minimize the effects of natural hazards.

GRADE 7
7.E1U1.6 Construct a model to explain how the distribution of fossils and rocks, continental shapes, and seafloor structures provides evidence of the past plate motions.

7.E1U2.7 Analyze and interpret data to construct an explanation for how advances in technology have improved weather prediction.

GRADE 8
8.E1U1.6 Analyze and interpret data about the Earth's geological column to communicate relative ages of rock layers and fossils.

8.E1U3.7 Obtain, evaluate, and communicate information about data and historical patterns to predict natural hazards and other geological events.

PRE-VISIT ACTIVITY

CLOUDS, CLOUDS, EVERYWHERE CLOUDS!

GRADES K-2

CLOUDS, CLOUDS, EVERYWHERE CLOUDS!

OVERVIEW

Students learn about the world around them through observation (seeing, smelling, tasting, touching and hearing) and asking questions. Students have seen clouds in the sky and they learn about clouds and weather patterns by watching the sky. Different types of clouds mean different types of weather. By recognizing different clouds, students can begin to understand weather patterns or changes and make predictions.

BACKGROUND

There is air all around Earth's surface, but there is less and less farther away from the surface (higher in the sky). Weather is determined by the conditions and movement of the air. The temperature, pressure, direction, speed of movement and the amount of water vapor in the air combine to create the weather. Measuring these properties over time enables patterns to be found that can be used to predict the weather a short time ahead.

MATERIALS

- Cloud Journal (optional)
- Clouds, Clouds, Everywhere Clouds! graphic organizer
- Cotton balls
- Crayons
- Markers
- Pencil
- Glue
- *The Cloud Book* by Tomie DePaola

ARIZONA STANDARDS

K.E1U1.3 Observe, record, and ask questions about temperature, precipitation, and other weather data to identify patterns or changes in local weather.

5E LEARNING CYCLE

ENGAGE

Hook students by showing the Cloud in a Bottle Demonstration here.

After viewing one of the demonstration videos, invite students to discuss what they know about clouds and their connection to weather (precipitation, temperature, etc.). Some questions could include: Do you like looking at clouds? What do clouds look like? Did you know there are different types of clouds? Why do you think there are different clouds? How do you think clouds are formed? Why do you think clouds are important?[1]

CLOUDS, CLOUDS, EVERYWHERE CLOUDS!

EXPLORE

Students will observe clouds daily for one week and record observations in their Cloud Journal. Encourage students to draw pictures and write about the clouds they see each day. Students should also record observations of precipitation, temperature, etc. After a week, students will be prompted to look through their Cloud Journals to see if there were any patterns, describe differences and discuss their observations.[2]

EXPLAIN

Read *The Cloud Book* by Tomie DePaola. Discuss the four types of clouds illustrated in the story and the corresponding weather. Prompt students to record their cloud observations on the Clouds, Clouds, Everywhere Clouds! graphic organizer.

EXTEND

Students will create a model of the four types of clouds using cotton balls, crayons, markers and glue.[3]

EVALUATE

Provide students with a half-sheet of paper. Students will be directed to choose one cloud they learned about throughout the lesson. Students will then write/draw characteristics about the cloud, what weather the cloud might produce, what temperature it is when that particular cloud is in the sky, and whether that cloud is seen often or not often where they live. Students will be given time to complete and then will be able to share with peers.[4]

CLOUDS, CLOUDS, EVERYWHERE CLOUDS!

DIFFERENTIATION SUGGESTIONS

1. Take students outside to look at the clouds, or show them pictures of different types of clouds to refer to during the discussion. For additional support, provide students with a list of adjectives that they can select from when describing the clouds.

2. Depending on the needs of the students, this activity can be completed whole-group, small-group, with a partner or independently.

3. Show students pictures of the four types of clouds to reference while creating their models.

4. Ask students to draw a picture of one type of cloud they learned about. Select one question for them to answer about the cloud. Depending on the needs of your students, you can ask them to write their answers or verbally share with a partner.

PRE-VISIT ACTIVITY

THE SPEED OF WIND

GRADES 3-5

THE SPEED OF WIND

OVERVIEW

This activity focuses on how anemometers are designed to measure the speed of wind. Students will work in groups to design, build and test an anemometer made out of everyday materials and learn about some practical applications for anemometers. Students must also develop a way to measure and chart the rotations of their anemometers.

BACKGROUND

An anemometer is a device that is used for measuring wind speed, and is usually found at weather stations. They can also be used to determine if a location is feasible for wind turbines, the wind speed of tornadoes and hurricanes, and to test the aerodynamics of airplanes. The term is derived from the Greek word *anemos*, meaning wind. The first anemometer was invented by Leon Batista in 1450 and later improved upon by Leonardo da Vinci.

RESOURCES

This lesson was modified from tryengineering.org

More information on anemometers here

ARIZONA STANDARDS

4.E1U1.8 Collect, analyze, and interpret data to explain weather and climate patterns.

MATERIALS

- Hairdryer or fan with multiple speed settings
- One set of the following materials for each group of students:
  - Plastic spoons
  - Paper cups
  - String
  - Tape
  - Scissors
  - Wire
  - Straws
  - Wooden sticks
  - Small wooden (balsa) pieces
  - Bendable wire (such as florist or craft wire)
  - Paperclips
  - Rubber bands
  - Toothpicks
  - Aluminum foil
  - Glue
  - Paper
  - Cardboard
  - Plastic wrap
  - Any other materials you might have available
- Graph paper and pencils for charting results

THE SPEED OF WIND

5E LEARNING CYCLE

ENGAGE

How do scientists measure wind speeds during tornados and hurricanes? Show this movie clip from *Twister*.

Did anyone notice the device attached to the truck at the beginning of the scene? Restart the clip and pause at 12-13 seconds. Ask students what they think this device is and what it does.[1]

EXPLORE

Divide students into groups of 2-3. Explain that each group must develop their own working anemometer from everyday materials. They must also devise a way to measure and record the relative speed of the wind as indicated by their anemometer. Show students the materials available to build their anemometers.

Groups should develop and draw a plan for their anemometer, and create a materials list before gathering their materials. As the groups build their anemometers, they may need to rethink their plan and request other materials. If they do so, they must revise their drawing and materials list. They will also need to devise a way to count revolutions and chart their results as wind speeds change. *Note: You may wish to make the "wind" available during the building phase so they can test their anemometer during the building phase prior to the final classroom test.*

Teacher Tips: In order to measure the relative wind speed, students will likely measure the number of revolutions of their anemometer, so you may need to guide them to color one of the wind catchers differently than the others so that it is easier to count revolutions. Also, the top portion must freely spin without resistance, therefore using a straw or pointed object on which the top piece will spin is ideal.

Each group will briefly present their design to the class, discussing how they came up with the design and what modifications they had to make as they built it. Then they will test their design as the other groups observe. Students should make note of what worked and didn't work in each design. The groups should do three tests at each wind speed (low, medium, high) for a total of nine tests. The three tests should be averaged to give a relative wind speed for each speed. Results can then be charted as the students see fit.[2]

THE SPEED OF WIND

EXPLAIN

Have students discuss what design features of their anemometers seemed to work best and any other observations they want to share. Show students some photos of real anemometers that illustrate how they have evolved over time (see resources), and compare and contrast them to the anemometers they built. Is there an energy conversion happening when an anemometer "catches" the wind? What type of energy is the wind being converted into?

EXTEND

What other uses do you think there might be for anemometers? Examples: weather stations, feasibility tests for wind turbine locations, airports, to determine high wind forces on bridges and tall buildings, aircraft testing, testing ventilation systems, etc.

Why is it important to know the speed of the wind in certain situations?

If your anemometer was used to test a location to see if it would be a good site to install a wind turbine, do you think that three tests would be enough to generate a reliable average? Why or why not? If not, how many tests do you think would be adequate?

What other features might an anemometer for this purpose need to have?

EVALUATE

Each group will self-evaluate their designs by answering the following questions:[3]

1. Did your design succeed in measuring wind speed?
2. How did your device measure the relative speed of the wind?
3. What worked well in your design and what didn't work as you planned? Did you have to modify your original plan at all? If so, what did you change?
4. If you had even more time and materials, how would you change your design?

THE SPEED OF WIND

DIFFERENTIATION SUGGESTIONS

1. Ask students to research anemometers. Discuss what they look like and how they work. Have pictures of anemometers available for students to reference during the "explore" phase.

2. Model for students how to test their model and chart data. For additional support, provide students with a data chart to complete.

3. Give students more support by providing them with a choice of how to show their understanding. This may include drawing pictures, giving a verbal presentation, recording themselves answering the questions verbally or completing provided sentence stems.

PRE-VISIT ACTIVITY

A ROCKY HISTORY

GRADES 6-8

A ROCKY HISTORY

OVERVIEW

Students will interpret data that illustrates the various rocky layers of Earth to tell a story about Earth's changing environments.

BACKGROUND

Scientists have been able to uncover amazing details about our planet's history by diving into the different rock layers that make up our planet. Amidst these layers, scientists are not only able to uncover the estimated age of Earth, but they're also able to uncover Earth's past environments by studying fossil evidence, as seen in certain rock types.

MATERIALS

- Science journals (1 per student)
- Pen/pencil (1 per student)
- Grand Canyon Handout (1 per student group)
- A Rocky History Handout (1 per student group)
- Learning From Fossils Handout (1 per student group)

ARIZONA STANDARDS

8.E1U1.6 Analyze and interpret data about the Earth's Geological column to communicate relative ages of rock layers and fossils.

5E LEARNING CYCLE

ENGAGE

Prompt students to draw what they think a canyon wall may look like in their science journals.[1] Allow students to have enough time to draw their ideas, but ensure students that they do not need to make their drawings perfect.

Circulate around the room and notice trends that you see in students' drawings. Facilitate a class discussion by asking several students to suggest some features that they might see on the canyon walls.

Ask students what they think the rocks could tell us about Earth's history. Prompt them to discuss their ideas with their shoulder partner. Once students have spoken with their partners, come back to the whole class and call on groups to share their responses.

Add to student's ideas that geologists use their observations of rock layers to tell the story of Earth's past. One way geologists are able to understand so much about the Earth's past is by evaluating the arrangement of rock layers in an environment.

A ROCKY HISTORY

EXPLORE

Distribute the Grand Canyon Handout to students. Prompt them to make observations of the image. Select students to share their observations.

Explain to students that each layer of the Grand Canyon has a unique story that reveals something about Earth's history. These layers may contain different fossils that reveal how the environment has changed over time.

Distribute the Learning From Fossils Handout and A Rocky History Handout to students. Tell them that the fossils in the pictures were all found in the Grand Canyon, and to pay attention to the name of the fossil and their descriptions to sort them into the layer they think they were found in. Remind them to apply your understanding of rock layers to help them do so.

Prompt students to begin sorting the fossils into the different layers on A Rocky History Handout. Allow enough time to prompt discussion about the different fossils in their groups. Encourage students to pay attention to the descriptions of each fossil, and to think about why they put certain fossils in different layers. Students should be prepared to share justifications for sorting after the activity.

EXPLAIN

Once students have discussed with their groups and sorted their cards, facilitate a class discussion explaining how each layer illustrates a different environment that changed over time. Tell students that during the activity, they sorted the fossil images into the appropriate rock layers based on the characteristics of the fossils, as well as their understanding of rock layers. Ask them to explain how their group decided to sort the fossils.

Explain to students that scientists use the Law of Superposition to help them figure out how old fossils are. The Law of Superposition states that the oldest layer of rock is on the bottom, and the youngest layer of rock is on the top. Following the Law of Superposition, we know that the bottom layer of a rock formation is always going to be the oldest layer. This means that the bottom layer can show geologists what the environment originally looked like.[2]

Prompt students to take a look at the fossils they placed in the bottom layer/Layer 3. Ask students: What assumptions can we make about one of the first environments at the Grand Canyon?

A ROCKY HISTORY

EXTEND

Direct students to take some time to research Pangea and learn more about the process it went through in order for the continents to arrive at their current locations. Prompt students to research this prompt through a variety of sources: Searching online, reading books/texts, discussing with a caregiver and/or watching videos.[3]

EVALUATE

After students complete their research, prompt them to create a diagram illustrating the movement of tectonic plates over time. Their diagrams should include one giant landmass separating into several landmasses, as the land masses were once pieced together like a puzzle and have moved over time, taking the fossils with them.[4] Once students complete their diagrams, have them displayed around the classroom for student viewing.

DIFFERENTIATION SUGGESTIONS

1. Engage prior knowledge by asking students to think about the Grand Canyon. Ask students to discuss with a partner what they think the Grand Canyon looks like before drawing their ideas.

2. If students need additional clarification, explain that we can think of rock layers like baking a layered cake. We start with the bottom layer first and work our way up. The oldest layer is on the bottom, and the newest layer is on the top.

   Display a labeled picture of rock layers, identifying the oldest layer on the bottom and the newest layer on the top, for students to reference.

3. Give students more support by providing specific websites or materials that they can use. Video resources are always a plus for our students who struggle with reading.

4. Provide students with a blank diagram. Ask them to draw arrows showing the movement of the tectonic plates over time.

For additional support, this activity can be completed as a whole group, small group, or with a partner.

BOOK YOUR FIELD TRIP TODAY!

If you have a group of 15 or more,
you are eligible for group discounts!
To schedule your field trip or group visit, head to
AzScience.Org.

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