5th Grade
Characteristics and Interactions of Earth's Systems

Teaching the Science and Engineering Education (SEEd) Standards

UVU College of Engineering & Technology
UTAH VALLEY UNIVERSITY

UVU CREATIVE LEARNING STUDIO

UVU School of Education
UTAH VALLEY UNIVERSITY

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Strand 5.1: Characteristics and Interactions of Earth's Systems

Matter cycles within ecosystems and can be traced from organism to organism. Plants use energy from the Sun to change air and water into matter needed for growth. Animals and decomposers consume matter for their life functions, continuing the cycling of matter. Human behavior can affect the cycling of matter. Scientists and engineers design solutions to conserve Earth's environments and resources.

Standard 5.1.1 Analyze and interpret data to describe patterns of Earth's features. Emphasize that most earthquakes and volcanoes occur in bands that are often along the boundaries between continents and oceans while major mountain chains may be found inside continents or near their edges. Examples of data could include maps showing locations of mountains on continents and the ocean floor or the locations of volcanoes and earthquakes. (ESS2.B)

Standard 5.1.2 Use mathematics and computational thinking to compare the quantity of saltwater and freshwater in various reservoirs to provide evidence for the distribution of water on Earth. Emphasize reservoirs such as oceans, lakes, rivers, glaciers, groundwater, and polar ice caps. Examples of using mathematics and computational thinking could include measuring, estimating, graphing, or finding percentages of quantities. (ESS2.C)

Standard 5.1.3 Ask questions to **plan and carry out investigations** that provide evidence for the effects of weathering and the rate of erosion on the geosphere. Emphasize weathering and erosion by water, ice, wind, gravity, or vegetation. Examples could include observing the effects of cycles of freezing and thawing of water on rock or changing the slope in the downhill movement of water. (ESS2.A, ESS2.E)

Standard 5.1.4 Develop a model to describe interactions between Earth's systems including the geosphere, biosphere, hydrosphere, and/or atmosphere. Emphasize interactions between only two systems at a time. Examples could include the influence of a rainstorm in a desert, waves on a shoreline, or mountains on clouds. (ESS2.A)

Standard 5.1.5 Design solutions to reduce the effects of naturally occurring events that impact humans. *Define the problem, identify criteria and constraints, develop possible solutions using models, analyze data from testing solutions, and propose modifications for optimizing a solution.* Emphasize that humans cannot eliminate natural hazards, but they can take steps to reduce their impacts. Examples of events could include landslides, earthquakes, tsunamis, blizzards, or volcanic eruptions. (ESS3.B, ETS1.A, ETS1.B, ETS1.C)

5.1.1 Exploring Earth

Grade: 5th

Lesson Topic: Earth's features-volcanoes and mountains

Utah SEEd Standard:

Standard 5.1.1 Analyze and interpret data to describe patterns of Earth's features. Emphasize that most earthquakes and volcanoes occur in bands that are often along the boundaries between continents and oceans while major mountain chains may be found inside continents or near their edges. Examples of data could include maps showing locations of mountains on continents and the ocean floor or the locations of volcanoes and earthquakes. (ESS2.B)

Lesson Performance Expectations:

- Students will obtain information on the patterns of locations of earth's features.
- Students will analyze and interpret data of the patterns of earth's features and why they are located where they are.

Phenomenon: Earthquakes and volcanoes are often located along the boundaries between continents and oceans while mountains are found inside continents or near their edges.
https://www.youtube.com/watch?v=Be7o6BYVOzA

Gather

1. Students will obtain information about the locations of volcanoes and mountain ranges in order to observe the patterns of their locations.
2. Students will plan and carry out an investigation to discover what common patterns happen where volcanoes and mountains are (ie. earthquakes).

Reason

3. Students will analyze and interpret data in order to observe the patterns between earthquakes, volcanoes, mountains, and more of earth's features.

Class Discussion:
Questions to initiate Discussion:
Q: Where do you find earthquakes?
Q: What common features are often also in areas where you observed earthquakes?
Q: Do you think there is any correlation between earthquakes, mountains, and volcanoes? Explain your reasoning.
Q: Do you think there is a correlation between the locations of mountain ranges and the locations of volcanoes? Explain your reasoning.

Communicate Reasoning 4. Students will develop an argument to explain why or why not they feel that earthquakes correlate with the locations of volcanoes and mountains based on patterns they observed.	
Science and Engineering Practices Obtain information Plan and carry out an investigation Analyze and interpret data Develop an argument	Obtain information and plan and carry out an investigation in order to explain the phenomenon. Analyze and interpret data in order to observe common patterns between features. Develop an argument to explain the phenomenon.
Crosscutting Concepts Patterns	Observe patterns in order to make predictions.
Disciplinary Core Ideas Earth science-earth's features	Earthquakes and volcanoes are often located along the boundaries between continents and oceans while mountains are found inside continents or near their edges.

Appendix A - Student Prompts for the Lesson

Phenomenon: Earthquakes and volcanoes are often located along the boundaries between continents and oceans while mountains are found inside continents or near their edges.

Group Performances:

1. Students will obtain information about the locations of volcanoes and mountain ranges in order to observe the patterns of their locations.
2. Students will plan and carry out an investigation to discover what common patterns happen where volcanoes and mountains are (ie. earthquakes).
3. Students will analyze and interpret data in order to observe the patterns between earthquakes, volcanoes, mountains, and more of earth's features.

Class Discussion

Individual Performances:

4. Students will develop an argument to explain why or why not they feel that earthquakes correlate with the locations of volcanoes and mountains based on patterns they observed.

Lesson Steps:

1. Show This Video to introduce volcanoes and mountain ranges. Discuss the following terms and definitions. Be sure to mention that engineers build machines to detect changes in the earth's surface.
    a. Volcanos-a vent in the earth's crust through which lava, steam, ashes, etc., are expelled, either continuously or at irregular intervals.
    b. Mountains- A natural elevation of the earth's surface rising more than 2,000 feet
    c. Ring of Fire- The Ring of Fire is a region around much of the rim of the Pacific Ocean where many volcanic eruptions and earthquakes occur.
    d. Lithosphere- Earth's outer solid crust.
    e. Asthenosphere- Molten upper portion of the mantle
    f. Tectonic plates- Earth's outer solid crust separated into plates that move over the asthenosphere. Their movement over time causes mountains, earthquakes, and volcanic eruptions to occur.
    g. Magma-molten material beneath or within the earth crusts
2. Introduce google earth to students.
3. Have students use google earth to identify features that occur around mountains and volcanoes. They also need to identify places where earthquakes happen frequently (on fault lines).
    a. Use the blank maps provided in appendix b for them to fill out places around the world where they find earthquakes, volcanoes, and mountains. They can color code and label the names of these as well.
4. Show maps listed in appendix b for more information.
5. Hold a class discussion to talk about what the students have observed and to help them begin to analyze the information they have found (questions can be found above in the Reason section).
6. When they have identified these features, students analyze the information to find patterns and create an argument to explain the patterns between earthquakes, volcanoes, and mountains.

Appendix B -

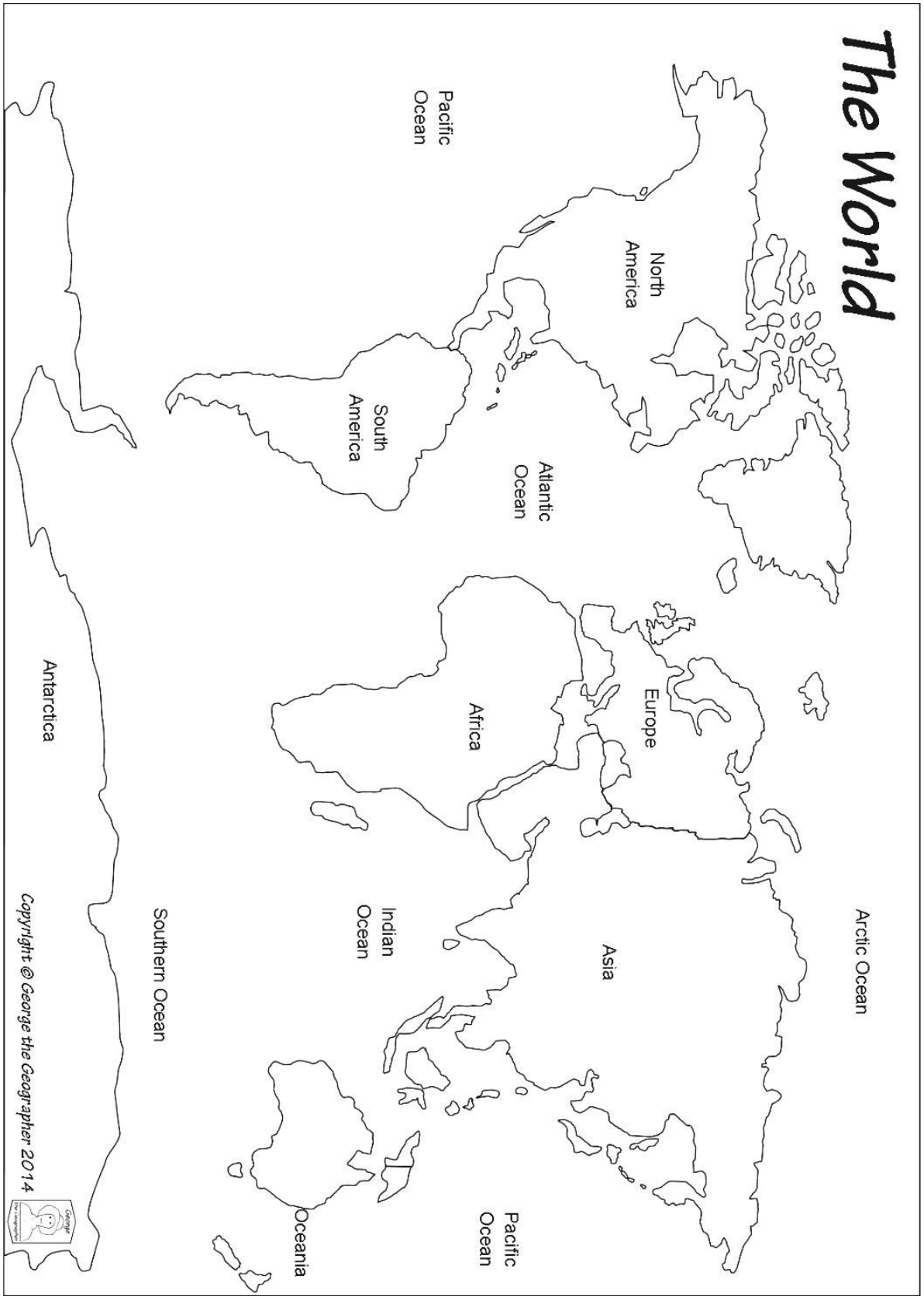
Students can use google earth education to explore the locations of earth's features at the beginning of class, when obtaining information (access to google earth will be needed in the classroom)
https://earth.google.com/web/@7.3806091,-112.92252998,2387.22099537a,28576888.00374985d,35y,-0h,0t,0r?hl=en

https://www.nationalgeographic.org/encyclopedia/ring-fire/?utm_source=BibblioRCM_Row

Ring of Fire Article-National Geographic grades 5-8

https://www.nationalgeographic.org/encyclopedia/mount-everest/?utm_source=BibblioRCM_Row Mount Everest-National Geographic grades 5-8

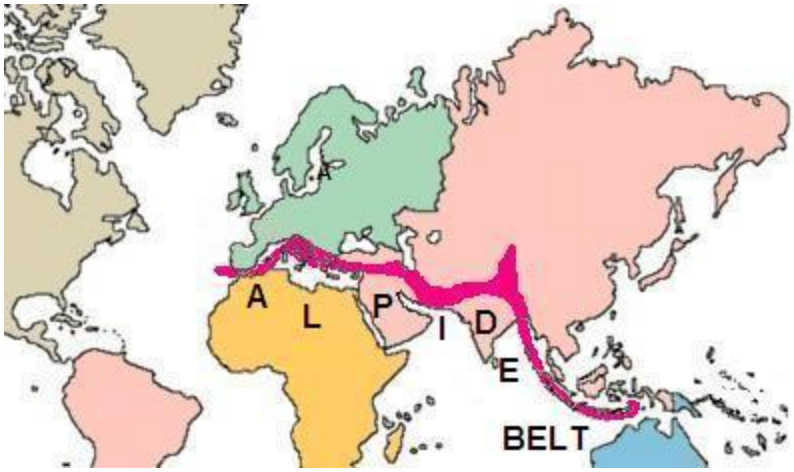
https://www.worldatlas.com/articles/what-is-the-alpide-belt.html Alpide Belt


The World
North America
Pacific Ocean
Atlantic Ocean
South America
Europe
Africa
Asia
Arctic Ocean
Indian Ocean
Pacific Ocean
Oceania
Antarctica
Southern Ocean
Copyright © George the Geographer 2014

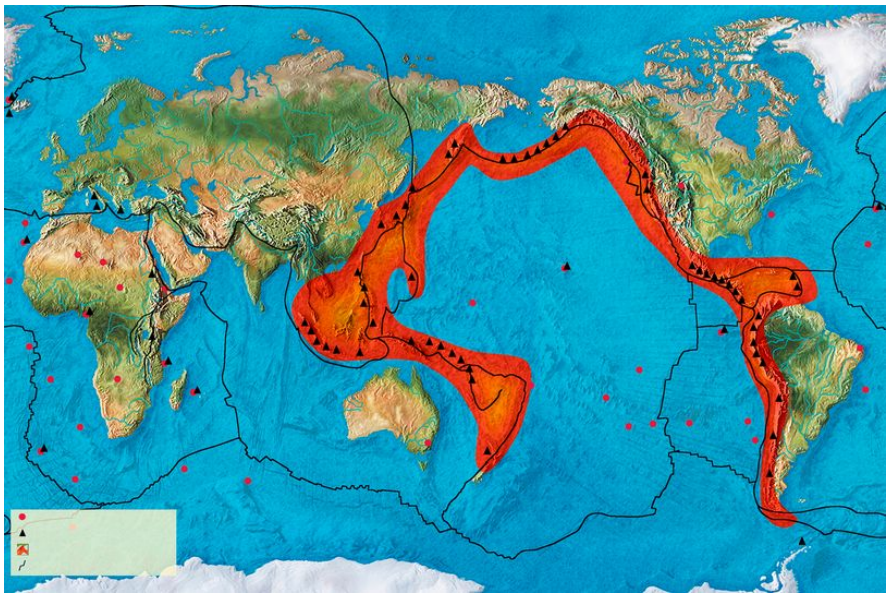
Use the world map above to have students label earth's features that they discover.

Can be used to have students draw the ring of fire.

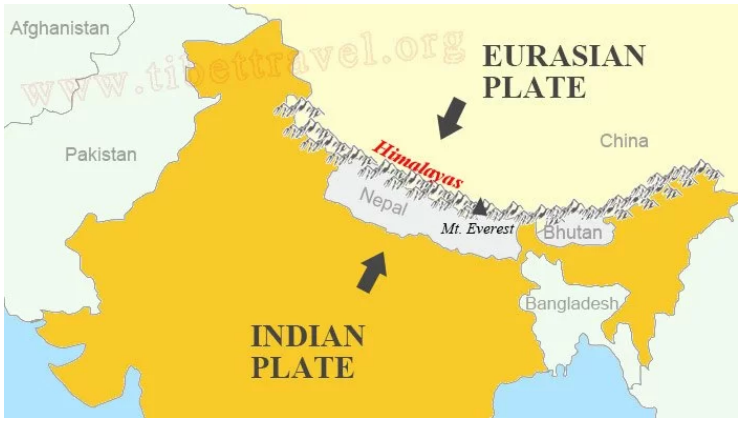
Ring of Fire, many earthquakes appear along here



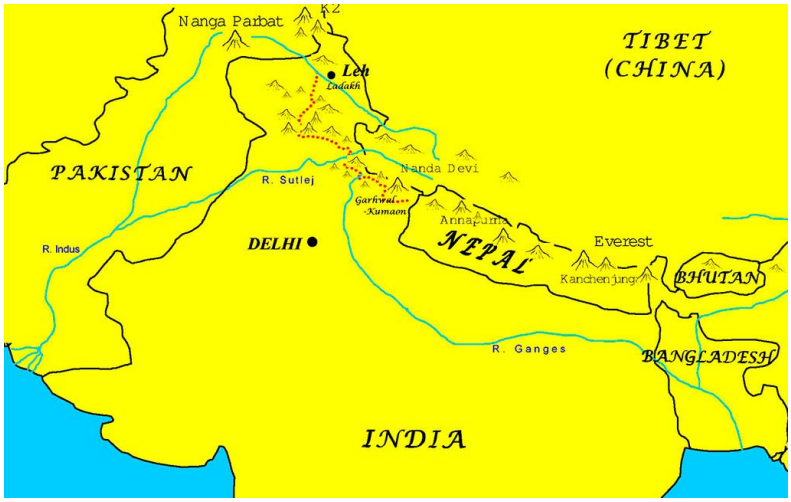
Alpide Belt, across the Middle East and southern Asia mostly. Many earthquakes appear along here.



Mountain ranges in the USA-Fault line occurs near Sierra Nevada



Himalayan Mountain Range




North American plate
Eurasian plate
North American plate
Juan de Fuca plate
Caribbean plate
Arabian plate
Indian plate
Filipino plate
Pacific plate
Cocos plate
EQUATOR
African plate
Pacific plate
Nazca plate
South American plate
Australian plate
Scotia plate
Pacific plate
Antarctic plate

5.1.2 So Salty

Grade: 5th

Lesson Topic: Bodies of saltwater and freshwater

Utah SEEd Standard:

Standard 5.1.2 Use mathematics and computational thinking to compare the quantity of saltwater and freshwater in various reservoirs to provide evidence for the distribution of water on Earth. Emphasize reservoirs such as oceans, lakes, rivers, glaciers, groundwater, and polar ice caps. Examples of using mathematics and computational thinking could include measuring, estimating, graphing, or finding percentages of quantities. (ESS2.C)

Lesson Performance Expectations:

- Use models to organize data about the quantity of saltwater and freshwater in various reservoirs.
- Use a model (graph) to compare the proportions of saltwater to freshwater on Earth.

Phenomenon: If you put all the freshwater on Earth into the ocean, it would still be salty.

Gather

1. Students will explore by tasting a drop of water from a cup of 3.5% salt and then tasting again after adding 10 ml of freshwater. (Students will taste by dipping their finger, stirring stick or a Q-Tip in the cup and tasting it)
2. Students will then ask questions about the distribution of saltwater and freshwater reservoirs on earth.
3. Students will obtain data from reliable sources about the distribution of saltwater and freshwater reservoirs on earth. (scale and proportion)
4. Students use a model (graph) to organize data about the quantity of saltwater and freshwater in various reservoirs.

Reason

5. Students analyze data to find the proportion of saltwater and freshwater on Earth.
6. Students use a model (graph) to show the proportion of water in the various reservoirs that provide evidence about the distribution of water on Earth.

Class Discussion:

Questions to initiate Discussion:

Q: How does the size of the ocean cause all water going into the ocean to become saltwater?

Q: What is the percentage of salt in the ocean?

Q: How does freshwater change when it becomes saltwater?
Q: Can saltwater become freshwater? What would that process look like?
Q: Does the location affect whether there is more water?
Q: Were then any patterns you observed? What were they?
Q: Why is there more saltwater than freshwater on earth?
Q: Where is the salt in saltwater?

Communicate Reasoning

7. Students will use the model (graph) to compare the proportions of saltwater to freshwater found on Earth.

Science and Engineering Practices Ask Questions Analyze and Interpret Data Develop and use models	Compare data and use comparisons as evidence Use representations to generate evidence Share science findings in written and graphic presentations to others Distinguish between representation and the actual object and/or phenomena represented in a model
Crosscutting Concepts Scale, Proportion, and Quantity	Use proportion and quantity to present phenomena. Use scale, proportion, and quantity to model systems. Use ratio to support explanations
Disciplinary Core Ideas Earth Systems	Nearly all of Earth's available water is in the ocean. Most freshwater is in glaciers or underground; only a tiny fraction is in streams, lakes, wetlands, and the atmosphere. (5-ESS2-2)

The original Lesson came from This Link and was transferred to its current format.

Appendix A - Student Prompts for the Lesson

Phenomenon: If you put all the freshwater on Earth into the ocean, the ocean would still be salty.

Group Performances:

1. Explore the tasting of a drop of water from a cup of 3.5% salt and then tasting again after adding 5 ml of freshwater. (dip your finger in the cup and taste on your finger)
2. Ask questions about the distribution of saltwater and freshwater reservoirs on Earth.
3. Obtain data from reliable sources about the distribution of saltwater and freshwater reservoirs on Earth.

4. Use models to organize data collected about the quantity of water in various reservoirs on Earth.
5. Analyze data about the relative proportion of water in the various reservoirs on Earth.
6. Use a graph to show the relative proportion of water in the various reservoirs on Earth.

Class Discussion

Individual Performances:

7. Use a graph to compare the proportions of saltwater to freshwater on Earth.

Lesson Steps:

1. Introduce the phenomenon by giving each student a cup (100 ml) of saltwater to taste by dipping a finger into the water or using a pipette to put some water on their hand to taste. Then add about 3 - 5 ml of freshwater and ask them to taste again. 1 - Can be done as a demo, but better if individual. **Do not** let students drink the water and make sure their hands are clean so as to prevent the spread of germs. Spend some time discussing what is meant by "reservoirs" with students. **Appendix B** has a lot of good websites for the data you need.
2. Introduce vocabulary for the lesson. Mention that engineers build water purifiers to make fresh water to drink. They also build machines that help test the salt levels in the water.
    a. Reservoir- An enlarged natural or artificial lake, pond, or impoundment created using a dam or lock to store water.
    b. Distribution-sharing over many groups, or spread over an area.
    c. Fresh Water- water that does not have salt in it.
    d. Brackish Water- Water that contains a little bit of salinity, but not as much as seawater does.
    e. Proportion- a part or a share that is being compared to a whole.
    f. Graphs- a collection of data on a diagram that shows a relationship between amounts (two).
3. Students will have a discussion about the distribution of freshwater and salt water reservoirs on earth.
4. Using the websites below, and supplementary ones, research the distribution of saltwater and freshwater reservoirs.
    a. If needed - This is a good place to have a discussion about the type of graph (line, bar, pie) that best represents the data.
5. Students will decide which type of graph to use in order to show the data they have gathered. They will work in small groups to graph the gathered data and then present it to the class.
    a. Prior to graphing, students should have small group discussions to talk about the data they gathered, what type of graph to use, etc.

Appendix B -

Materials:

Provided Material:

- Pipettes
- Small cups for each student to measure water

Classroom Materials:

- Paper
- Rulers
- Pencils etc. for creating the graphs
- Water
- salt

Gathering Teaching Suggestions:

Data Source - You may wish to use this site to obtain information about the relative amounts of saltwater and freshwater on Earth. https://water.usgs.gov/edu/earthhowmuch.html
Describes the proportion of saltwater to freshwater on Earth.
https://phys.org/news/2014-12-percent-earth.html
Pie Chart Source: https://dnr.mo.gov/education/water-resources.htm

Reading Passage for students to obtain information
http://www.k12reader.com/reading-comprehension/Gr5_Wk23_Water_Water_Everywhere.pdf
National Groundwater Association
http://www.ngwa.org/Fundamentals/teachers/Pages/information-on-earth-water.aspx

Reasoning Teaching Suggestions:

Selecting the appropriate graph type
More resources - why is the ocean salty when fresh water is running into it
ocean salinity

5.1.3 Hillside Erosion

Grade: 5th

Lesson Topic: Earth's Systems- Erosion

Utah SEEd Standard:

Standard 5.1.3 Ask questions to **plan and carry out investigations** that provide evidence for the effects of weathering and the rate of erosion on the geosphere. Emphasize weathering and erosion by water, ice, wind, gravity, or vegetation. Examples could include observing the effects of cycles of freezing and thawing of water on rock or changing the slope in the downhill movement of water. (ESS2.A, ESS2.E)

Lesson Performance Expectations:

- Develop questions to design a solution for the problem of hillside erosion following forest and/or brush fires.
- Obtain information from reliable sources for the cause of hillside erosion and ways to reduce hillside erosion.

Phenomenon: Canyons across Utah are seeing dirt and debris being washed onto streets during rainstorms.

Landslides- Riverdale, Cedar City, Big Bear creek/Seely Creek, Thistle LS2
Provo Canyon Mudslide- Provo Canyon
in payson canyon, in blanding, little cottonwood canyon , weber canyon.

Gather

1. Students develop questions that they can use to investigate the causes of hillside erosion following a brush/forest fire and identify problems caused by the fires.
2. Students will plan and then carry out an investigation to obtain information about how the atmosphere, hydrosphere, and geosphere interact to cause hillside erosion following forest and brush fires.

Reason

3. Students develop a model showing the interaction of the atmosphere, hydrosphere, and geosphere that cause the changes to the interactions of these systems on burnt hillsides.
4. Students will find solutions (engineer) to the problem of how to slow down the rate of erosion caused by the interaction of the atmosphere, hydrosphere, and geosphere.

Class Discussion:
Questions to initiate Discussion:
Q: How does forest/brush fires affect the structure of a hillside?
Q: What are some ways we can stabilize a hillside after a fire?
Q: What causes the erosion? How is this a problem?
Q: What changes can we make to solve the problem (preventing erosion)?
Q: What things were not effective?
Q: Are there patterns in erosion? What did you notice in the erosion when you placed objects around the sand?
Q: Why did you choose the materials you did to try to prevent the erosion of the hillside?
Q: How can we best develop housing on hillsides in ways that prevent hillside erosion?

5. Students will construct an explanation for how their solution reduces or prevents hillside erosion after a forest/brush fire.

Communicate Reasoning

6. Students develop an argument for how the evidence they have collected from the investigation supports the design of their solution to make the hillside more stable and prevent erosion.

Science and Engineering Practices Plan and carry out an investigation Develop and Using models Construct an explanation Develop an argument	Use the investigation to gather evidence. Use a model to make sense of the phenomenon Develop an explanation for the causes of phenomena. Use evidence to develop an argument for the causes of phenomena.
Crosscutting Concepts Stability and Change Cause and effect Structure and function	Natural events are caused by the interaction of systems. Some changes happen quickly and some happen slowly. The structure of a system determines how the components of the system interact with other systems.
Disciplinary Core Ideas Earth and Universe - Interaction among the geosphere and hydrosphere Forces - Gravity	Earth's major systems are the geosphere (solid and molten rock, soil, and sediments), the hydrosphere (water and ice), the atmosphere (air), and the biosphere (living things, including humans). These systems interact in multiple ways to affect Earth's surface materials and processes. The ocean supports a variety of ecosystems and organisms, shapes landforms, and influences climate. Winds and clouds in the atmosphere interact with the landforms to determine patterns of weather. (5-ESS2-1)

	Gravity is a force that pulls things toward the Earth.

Lesson adapted from: **Hillside erosions**

Appendix A - Student Prompts for the Lesson

Phenomenon: Since the fire last year in the mouth of Weber Canyon, dirt and debris have been washing onto the streets during rainstorms.

Group Performance:

1. Develop questions that they can use to investigate the causes of hillside erosion following a brush/forest fire and identify problems caused by the fires.
2. Plan and then carry out an investigation to obtain information about how the atmosphere, hydrosphere, and geosphere interact to cause hillside erosion following forest and brush fires.
3. Develop a model showing the interaction of the atmosphere, hydrosphere, and geosphere that cause the changes to the interactions of these systems on burnt hillsides.
4. Find solutions (engineer) to the problem of how to slow down the rate of erosion caused by the interaction of the atmosphere, hydrosphere, and geosphere.

Class Discussion

5. Construct an explanation for how their solution reduces or prevents hillside erosion after a forest/brush fire.

Individual Performance: - Write in your Journal

6. Develop an argument for how the evidence they have collected from the investigation supports the design of their solution to make the hillside more stable and prevent erosion.

Lesson Steps:

1. Introduce the lesson by showing the landslide and mudslide videos that relate to the phenomenon Landslide and Provo Canyon Mudslide. Emphasize that Engineers design solutions to prevent mudslides and landslides and that is what they will be trying to design today.
2. Go over vocabulary words: Here is a song that introduces Earth's spheres. Earth's 4 Spheres song
    a. Hydrosphere- All of the water found on, above, the surface of the earth
    b. Geosphere- The solid earth in and of itself

   c. Atmosphere- The whole mass of air surrounding the earth
   d. Erosion - The process of wearing away by the action of water, wind, or glacial ice
   e. Rate - the speed at which the earth erodes
   f. Mudslide - a mass of mud and other earthy material that is falling or has fallen down a hillside or other slope
   g. Landslide - the sliding down of a mass of earth or rock from a mountain or cliff.
3. Students will investigate the cause of hillside erosion in small groups. This investigation should be done outside.
   a. They will identify problems that cause erosion after fires. Have students explore the powerpoint and website to learn more about weathering, erosion, and mudslides.
   b. One student will get a plastic container and bring it to the dirt supply for 1 small shovelful of dirt at one end of the plastic container.
   c. Another student gets one pipette for each member of the group and something to slightly tilt the plastic container.
   d. Another student gets a cup and fills it up with water.
   e. Students should set up their container so it flows evenly down to the low side of the container. (Slanting in more than one direction can cause water to accumulate in corners and cause unnatural features.)
   f. Add 100-150 mL of water to the lower end of the container to make a small lake.
   g. Everyone gets one pipette which can be used to drop (not squirt) onto the "mountain". 20 minutes to do this is optimal. Make note of erosional features because some features, such as sinkholes, slump, and landslides are very difficult to identify after they happen. Feel free to experiment with the height of the drop.
   h. After the investigation, students should clean it up.
   i. Steps for this investigation came from the ppt. Link below in appendix B.
4. After completing their investigation students will engineer a solution to the problem of slowing the rate of erosion caused by the interaction of the atmosphere, hydrosphere, and geosphere. They will then construct an explanation and argument for their solution based on evidence they have collected.
   a. In this performance, students build solutions to ways to reduce the runoff from a hillside that has had a fire. You might use examples of hillside fires such as the ones that occur in the foothills of Utah, Colorado, or California.

Student examples:



Appendix B -

Reading Links:

- https://wonderopolis.org/wonder/what-causes-mudslides
- http://blog.geiworks.com/2018/01/wildfires-part-two.html

Weathering and erosion powerpoint: www.nps.gov/tica/forteachers/upload/Erosion.pptx.

Provided materials:

- small plastic trees and bushes
- plastic wrap
- pipette
- graduated cylinder to measure and pour water
- Gray/White Bins
- sand or dirt to pack down on the containers

Classroom Materials:

- block or something to put under container to tilt it slightly
- Cardboard boxes
- Toothpicks (I usually can get these pretty easily if needed for extra materials for the students.)
- rocks
- string
- popsicle sticks
- straws

5.1.4 Interactions On Earth

Grade: 5th

Lesson Topic: Matter Particle and Geoscience Processes

Utah SEEd Standard:

Standard 5.1.4 Develop a model to describe interactions between Earth's systems including the geosphere, biosphere, hydrosphere, and/or atmosphere. Emphasize interactions between only two systems at a time. Examples could include the influence of a rainstorm in a desert, waves on a shoreline, or mountains on clouds. (ESS2.A)

Lesson Performance Expectations:

- Plan and then carry out investigations to provide/find evidence for the causes of changes in the ecosystems due to atmospheric interactions (Wind).
- Construct an explanation that is supported by evidence for how the quantity and velocity of wind determines the force transferred by air particles.
- Develop an argument for how and/or why the evidence from the investigation supports and explains the causes of the Lodgepole pines in Montana blowing down.

Phenomenon: Thousands of trees in the Lodgepole pine forest in Montana have been flattened down by what appears to be natural events.

Gather

1. Students will develop questions that will determine the effects of moving air (wind) on objects.
2. Students will plan and then carry out an investigation to help determine how the volume and speed of air (wind) affects the transfer of force from the atmosphere to objects.
3. Students will obtain information from the reading and other sources about the structure of Lodgepole pines.

Reason

4. Students construct an explanation supported by evidence for how the quantity and velocity of moving air determine the force transferred by the air.
5. Students construct an explanation supported by evidence they find/learn for the most likely causes of the Lodgepole pines in Montana blowing down.

Class Discussion:
Questions to initiate discussion:
Q: How does the lodgepole pine tree structure make them more likely (easier) to blow down than other trees?
Q: How does the wind transfer a force?
Q: Why do the trees blow down in large patches?
Q: Does the composition of soil affect the numbers of trees that are flattened down?
Q: What evidence do you have that the increase in volume of moving air increases the force on objects?
Q: Why are changes to the biosphere the result of interactions with the atmosphere?
Q: Can you think of other examples of interactions between the biosphere and the atmosphere?

Communicate Reasoning

6. Students will develop a model to show the force of wind acting on the trees, causing them to fall over.
7. Students will develop an argument for how the evidence they've gathered from the investigation and reading supports the group's explanation for how changes to the Biosphere (Lodgepole pines blowdown) were caused by a transfer of forces by the atmosphere.

Science and Engineering Practices Plan and carry out an investigation Construct an explanation Develop an argument	Use investigations to gather evidence. Develop an explanation for the causes of phenomena. Use evidence to develop an argument for the causes of phenomena.
Crosscutting Concepts Systems Cause and effect Structure and function	Natural events are caused by the interaction of systems. Changes in the motion of an object are caused by the motion of other objects. The structure of a system determines how the components of the system interact with other systems.
Disciplinary Core Ideas Earth Materials and Systems Matter Forces	Earth's major systems are the geosphere (solid and molten rock, soil, and sediments), the hydrosphere (water and ice), the atmosphere (air), and the biosphere (living things, including humans). These systems interact in multiple ways to affect Earth's surface materials and processes. The ocean supports a variety of ecosystems and organisms, shapes landforms, and influences climate. Winds and clouds in the atmosphere interact with the landforms to The matter is made of particles. The matter has mass and can transfer a force.

	Air is matter. The motion of an object is determined by the sum of the forces acting on the object.

Lesson adapted from- lodgepole pines blowdown

Appendix A - Student Prompts for the Lesson

Phenomenon: Thousands of trees in a Lodgepole pine forest in Montana are stacked into large piles by natural forces.

Group Performance

1. Develop questions that will determine the effects of moving air (wind) on objects.
2. Plan and then carry out an investigation to help determine how the volume and speed of air (wind) affects the transfer of force from the atmosphere using the following materials: *syringe, air, paper tubes, string, scotch tape, tape measure, Ping-Pong balls, knex and perhaps other things upon request.
3. Construct an explanation supported by evidence for how the quantity and velocity of moving air determine the force transferred by the air.
4. Obtain information from the reading and other sources about the structure of Lodgepole pines.
5. Construct an explanation supported by evidence they find/learn for the most likely causes of the Lodgepole pines in Montana blowing down.

Individual Performance - SSW

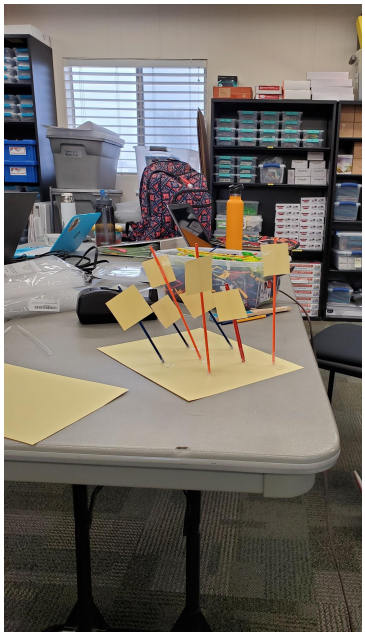
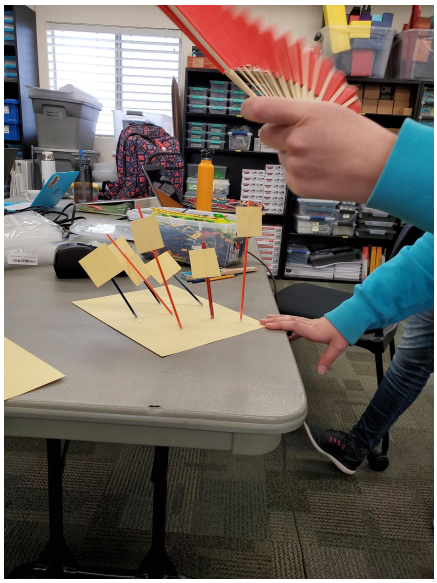
6. Students will develop a model to show the force of wind acting on the trees, causing them to fall over.
7. Students will develop an argument for how the evidence they've gathered from the investigation and reading supports the group's explanation for how changes to the Biosphere (Lodgepole pines blowdown) were caused by a transfer of forces by the atmosphere.

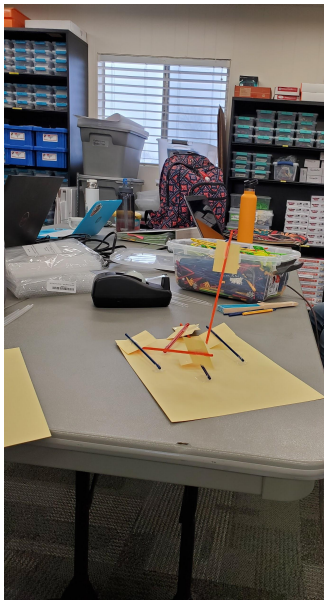
Lesson steps:

1. Introduce the lesson by discussing the phenomenon of the Lodgepole pines falling over in montana. Use this link to find more information. Be sure to mention that scientists and engineers develop models to show and test how earth's spheres interact.
    a. Vocab words
        i. Hydrosphere- All of the water found on, above, the surface of the earth

   ii. Geosphere- The solid earth in and of itself
   iii. Atmosphere- The whole mass of air surrounding the earth
   iv. Biosphere- all living things on earth

2. Walk students through the investigation. They will be in small groups of about 3 for this.
   a. Students will investigate how wind affects the movement of different objects. Using hand fans, they will measure how far a ping pong ball moves across a surface with varied forces of wind. They will use a tape measure to measure the length.
   b. They can use multiple ping pong balls next to each other to see what happens when they blow with the fan. Do the ping pong balls hit each other? Do they all move? They should record their observations.
   c. Student investigations may include measuring how the amount of air affects how far balls or straws are moved. Students should connect the idea that force is related to mass and velocity/speed of an object, so more air in the syringe - more mass,
   d. pushing the syringe fast causes the air to move faster.
3. Students will discuss their findings from the investigation. For questions to initiate discussion, see above in the Reason section.
   a. The class discussion should focus on students using evidence from the investigation that air has mass and transfers forces. The biosphere is affected by the atmosphere in many ways. Other considerations for the class discussion: 1. Structure of tree-tall thin, uniform growth, susceptible because of fast growth, 2. Mechanism for uprooting-lever of a tall tree, leaves at the top, 3. The soil is poor in nutrients and has a shallow root system, with no vegetation to hold roots in place. 4. Wind of downdraft-microburst, 120-150 mph winds, poor soil and low moisture, trees grow quickly. Not a large root system. 5. More wind, more force-syringe=volume & velocity, gusts to the grove of trees. Response to environment and adaptation-Individuals adapt but species survive, adaptation is a genetic trait over a period of time.
4. Students will design models to show how wind affects the lodgepole pines.
   a. Using construction paper as the base and K'nex to represent the trees, they can tape the k'nex on to represent a forest. Add a paper square to the top of each "pine" to simulate leaves.
   b. Use the hand fans to represent wind and show what happens to the "trees" when there is strong wind.
   c. The students can also use different heights of k'nex to show what happens with different sized lodgepoles.
   d. The students can also measure the distance between each "tree" and observe how the distance of them affects the results of the wind.

5.  

6. As an extension or to close the lesson, see in Appendix B for another reading about the Lodgepole pine habitat and an article about air being made of matter. This can be used to help the students understand the concept that air has mass and that's why it has force.

Appendix B -

Website:

Visit http://formontana.net/bolt.html this website to find out more information about the Lodgepole Pines blowdown. This website also has more pictures you can show students.

Readings:

Needs and Habitat of Lodgepole Pine Forests
Lodgepole pines grow best in soil that is slightly acidic. Lodgepoles are one of the trees that can most quickly reforest areas disturbed by fire or human activities such as road cuts or logging. These trees grow quickly in soils high in minerals. Lodgepole pine roots spread out sideways and do not grow deep into the ground so they do well in areas with shallow topsoil. However, these shallow roots may be a disadvantage in areas with high winds. Lodgepole pines are vulnerable in windstorms, especially in meadows or ridge tops.

Lodgepole pines can grow in conditions ranging from very wet ground to very poor soil such as found in the Rocky Mountains. Because Lodgepole pines are dependent on sunny conditions for a seedling to grow and survive, the seedlings often do not grow unless an opening **canopy (**large tree tops shading the ground) occurs. Lodgepole pines compete with other trees for sunlight, water, and space in the forest.

Air is Matter

Air is made of matter. The matter we encounter every day is made of particles that have mass. When particles collide with objects they transfer a force. The greater the mass the more force that is transferred. When an object is traveling faster it transfers more force.

When the wind is blowing faster, kites fly better. If air is not moving a kite cannot fly. The kite is held up in the air by the force of air particles hitting the kite. Wind causes flags to flap. The wind is moving particles of air that transfer a force to the flag. If you throw a baseball and hit a pop can move. The ball causes the pop can to move. The ball has mass and is moving so it transfers a force to anything it hits. If you throw the ball faster it moves the pop can more, if you throw a bigger ball, like a basketball, it moves the pop can further.

Materials:

Provided Material:

- Hand fans
- K’nex poles
- String
- Tape measure
- Ping-Pong balls

Classroom Materials:

- Scotch tape
- Rulers

5.1.5 Disaster Proofing

Grade: 5th Multi Day lesson

Lesson Topic: Earth Science-Natural Disasters

Utah SEEd Standard:
Standard 5.1.5 Design solutions to reduce the effects of naturally occurring events that impact humans. *Define the problem, identify criteria and constraints, develop possible solutions using models, analyze data from testing solutions, and propose modifications for optimizing a solution.* Emphasize that humans cannot eliminate natural hazards, but they can take steps to reduce their impacts. Examples of events could include landslides, earthquakes, tsunamis, blizzards, or volcanic eruptions. (ESS3.B, ETS1.A, ETS1.B, ETS1.C)

Lesson Performance Expectations:

- Students will define problems involved in the patterns that natural disasters have on human life.
- Students will design and test solutions to help create better structures and functions against the effect of natural disasters.

Phenomenon: *The effect of natural disasters can be lessened as humans work together to solve problems and create solutions.*

Gather

1. Students will define the problem that unwanted natural disasters can cause major destruction to human life and structures and functions of many things are not always designed with this in mind.
2. Students will obtain information on a natural disaster of choice in order to observe common patterns between the disaster and destruction caused.

Reason

3. Students will design a solution to improve the structure and function of buildings for their assigned natural disaster.
4. Students will evaluate information from their classmates in order to best improve their designs for the best structure and function.
5. Students will test their developed models in order to observe whether or not their designs will contradict the patterns they previously observed.

Class Discussion:
Questions to initiate Discussion:
Q: What is the problem that your natural disaster presents?
Q: In what ways is your group attempting to solve these problems?

Q: What problems have you run into with your design? Does anyone have any suggestions to help with these?
Q: What modifications could you use to help your design?
Q: Do you feel your design will help solve the real life problem caused by the natural disaster?

Communicate Reasoning

6. Students will develop an argument for whether or not they felt their design would provide fitting structure and function against the natural disaster.

Science and Engineering Practices Obtain information Plan and carry out an investigation Analyze and interpret data Develop an argument	Obtain information and plan and carry out an investigation in order to explain the phenomenon. Analyze and interpret data in order to observe common patterns between features. Develop an argument to explain the phenomenon.
Crosscutting Concepts Patterns	Observe patterns in order to make predictions.
Disciplinary Core Ideas Earth science-earth's features	Earthquakes and volcanoes are often located along the boundaries between continents and oceans while mountains are found inside continents or near their edges.

Phenomenon: *The effect of natural disasters can be lessened as humans work together to solve problems and create solutions.*

Group Performances:

1. Students will define the problem that unwanted natural disasters can cause major destruction to human life and structures and functions of many things are not always designed with this in mind.
2. Students will obtain information on a natural disaster of choice in order to observe common patterns between the disaster and destruction caused.
3. Students will design a solution to improve the structure and function of buildings for their assigned natural disaster.
4. Students will evaluate information from their classmates in order to best improve their designs for the best structure and function.

Class Discussion

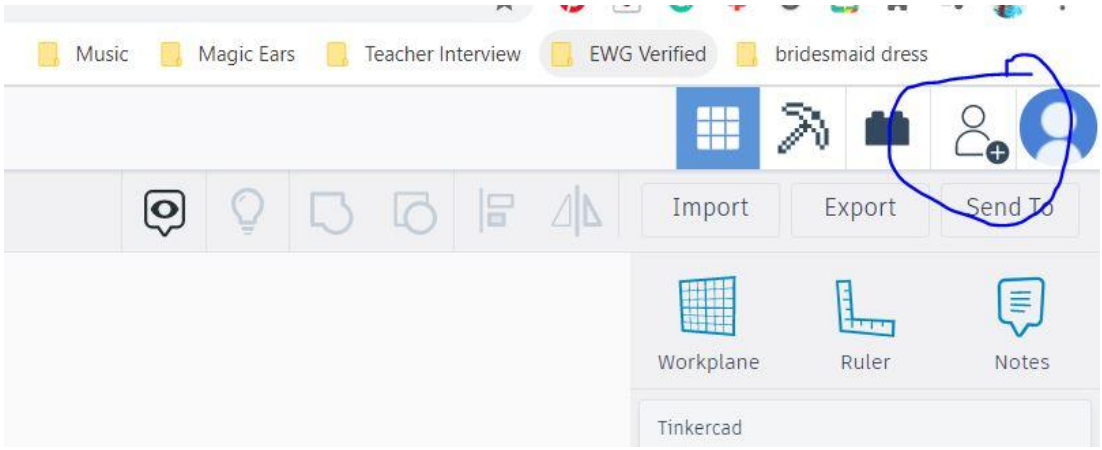
5. Students will test their developed models in order to observe whether or not their designs will contradict the patterns they previously observed.

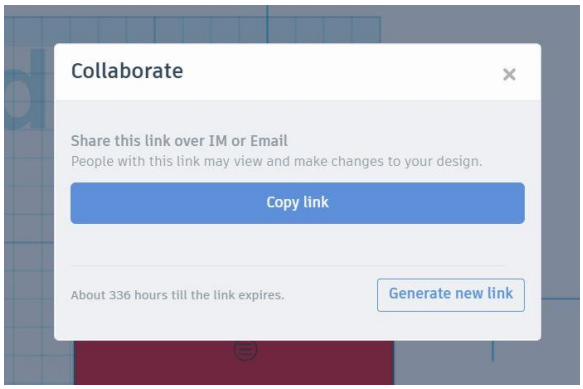
Individual Performances:

6. Students will develop an argument for whether or not they felt their design would provide fitting structure and function against the natural disaster.

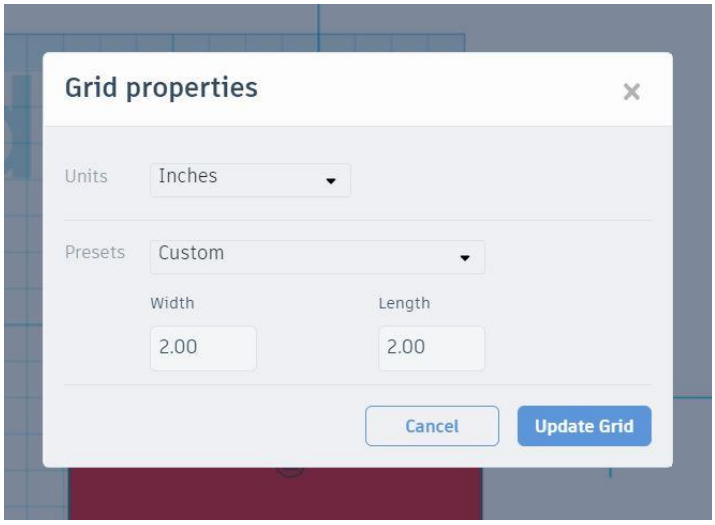
Teacher prep - You will need to create an account as an educator on tinkercad this will give you the ability to create a classroom and have students join your classroom where they can create their design. Instructions for Setting up a tinkercad classroom.

- *Assign each group to have a leader, they will create a design and then invite the other students to join their design in the upper right hand corner. This will allow groups to all work on the same design.*





- *There is a tutorial video on how to use the website and create your design. Students' solutions/designs will need to be small, no more than 2". There is a scale feature on the website.*



- *When going to print off their designs with the 3D printer, you as the teacher will*
    1. *Go to view class activity.*
    2. *Click on download.*
    3. *Download the design to the USB and as an .STL*
    4. *Make sure printer is on*
    5. *Insert Flash drive.*
    6. *Select downloads from the scroll down list and then select the design you want to print.*

7. *Click on the design and click print.*

Multi day lesson!!

Lesson Steps:

1. Introduce the lesson by introducing natural disasters, and talking about the effects of weather on the earth's surface. Be sure to mention that engineers design and build models to prevent the negative effects of natural disasters.
    a. Vocabulary
        i. Resistant- Incapable of being penetrated by the action of corrosive substances, heat, etc.
        ii. Weather-proofing- The act of creating something that's capable of withstanding exposure to weather without damage
        iii. Natural Disaster-a major adverse event resulting from natural processes of the Earth; examples include floods, hurricanes, tornadoes, volcanic eruptions, earthquakes, tsunamis, storms, and other geologic processes
        iv. Natural Hazard- A naturally occurring event that might have a negative effect on people or the environment.
2. Launch the Phenomenon: Students will be introduced to the idea of a natural disaster and that many structures need to be disaster-proofed to help minimize the effects these events have on humans.
    a. Using the Keva planks and orbital rotator shaker, have students design a structure that will withstand an earthquake.
    b. They will do this in small groups and it shouldn't take more than 15 minutes to introduce the lesson.
    c. They will each test their structures on the orbital rotator shaker.
3. Explore: Students will now explore deeper into a natural disaster.
    a. Students will be split into small groups of about 3 to work in.
    b. They will be assigned a natural disaster (flood, fire, earthquake, tsunami, volcanic eruption, blizzard). They will do research together on the causes of the natural disaster and will be tasked to design a solution to minimize the effects the weather will have on people. They can use the internet and any of the resources provided in the lesson to learn more about their assignment of natural disasters.
    c. They can talk together and discuss and brainstorm the solution they would like to create.
    d. Then they will create a model using the Tinkercad website (link is at the top of the lesson steps). This website is used to design creations for the 3D printer.
        i. Note: In order for the designs to print properly and quickly, they need to be small enough. Students can create designs to be printed in parts if this

is easier. Each piece printed at one time should be no more than 2 inches. See instructions above.

   e. Once they have created their solutions for the 3D printer, they can have them printed out.

4. Students will participate in a class discussion to present their printed designs to the class, explaining what their disaster was and how their design will minimize the problem.
   a. Students in the class can ask questions and give them critique for how they could revise their designs and make it better.
   b. For more questions to initiate discussion, see above in the Reason section.
5. Students will develop an argument for whether or not they felt their design would provide fitting structure and function against the natural disaster. This should be written out or given orally to the whole class.

Appendix B -

Provided Materials:

- *Orbital rotator shaker*
- *3D Printer*
- *Keva Blocks*

Classroom Materials:

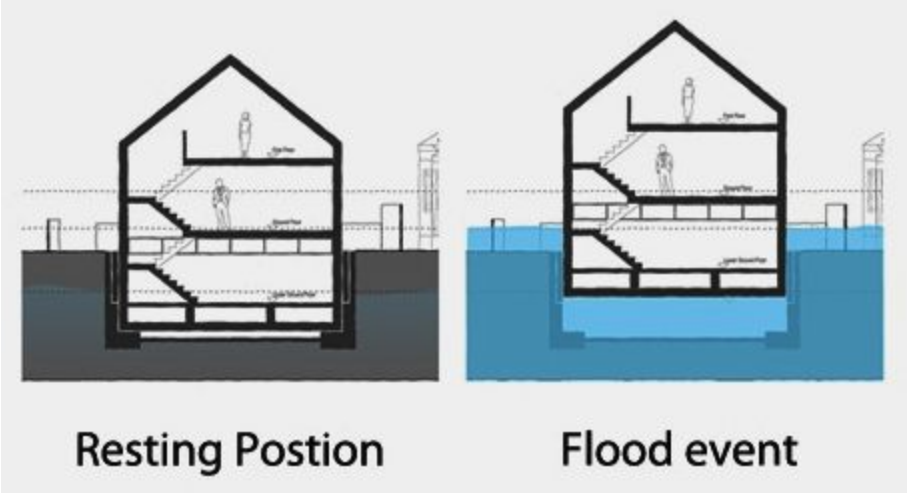
- Access to computers

how earthquakes affect Buildings *modify article for students needs*

how earthquakes affect structures *modify article*

Tsunami proof buildings

tsunami proof buildings in Japan *modify and shorten article*



Tsunami resistant building with stilts

Earthquake resistant building made with carbon fabric

Materials list by lesson:

5.1.1 Exploring Earth

Provided Material:

Classroom Materials:

- Access to internet

5.1.2 So Salty

Provided Material:

- Pipette (76)
- Small cups for each student to measure water (5)
- Salt (1)

Classroom Materials:

- Paper
- Rulers
- Pencils etc. for creating the graphs
- Water

5.1.3- Hillside erosion

Provided materials:

- Small plastic trees and bushes (18)
- Straws (2)
- Plastic wrap (4)
- Pipette (38)
- Graduated cylinder to measure and pour water (7)
- Plastic gray totes (8)
- Sand or dirt to pack down on the containers (1 Sand, 1 Dirt)

Classroom Materials:

- block or something to put under container to tilt it slightly
- Rocks
- popsicle sticks

5.1.4 - Interaction on Earth

Provided Material:

- Handfans (9)

- Tape measure (5)
- Ping-Pong balls (32)
- K'nex (5)

Classroom Materials:

- stape

5.1.5 - Disaster Proofing

Provided materials:

- *Orbital rotator shaker (1)*
- *3D Printer (1)*
- *Keva Blocks (1 box)*

Classroom materials:

- *Access to computers*

Procedure Cards

Orbital Rotator Shaker

1. Place the shaker on a flat even surface.
2. Plug in and turn on.
3. Place a pre-built structure on the shaker.
4. Set the timer to the desired length and turn the speed dial to desired intensity.
5. Wait until the timer is done to remove the structure and its pieces.
   Note: The shaker will not go unless the timer is on.