STEM Stories: Volcano Rising
Lesson Plan

STEM Career Connections: Civil Engineering, Chemical Engineering, Architecture and Construction

STEM Disciplines: Science, Technology, Engineering and Mathematics

Non-STEM Disciplines: English Language Arts

Design Challenge Problem/Scenario:

Mount St. Helens is about to erupt. Your task is to create a structure that will save the surrounding buildings before the flowing lava puts the civilians in danger. You have around 15 minutes to complete the task and save the buildings from the lava flow.

Engineering Design Challenge:

Your team's challenge is to create a structure that will change the flow of foam (lava) so that the flow does not touch the buildings.

Essential Question Students Investigate:

How can we create a structure that can divert the flow of lava (foam) away from the buildings?

Enduring Understandings:

- Using the engineering design process when approaching problems results in unique solutions.
- Collaboration and following the engineering design process lead to more creative and effective solutions to problems.
- The concepts of strength of materials and structural integrity are important for this problem. The design challenge is to create a structure sturdy enough to withstand the flow of the foam and to divert it around the buildings.

English Language Arts Standards:

- RL.3.1 Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for the answers.
- RL.3.4 Determine the meaning of words and phrases as they are used in a text, distinguishing literal from non-literal language.
- W.3.3 Write narratives to develop real or imagined experiences or events using effective technique, descriptive details, and clear event sequences.
- SL.3.4 Report on a topic or text, tell a story, or recount an experience with appropriate facts and relevant, descriptive details, speaking clearly at an understandable pace.
- SL.3.6 Speak in complete sentences when appropriate to task and situation in order to provide requested detail or clarification.

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Science Standards:

Science Inquiry and Applications, Technological and Engineering Design
During the years of PreK to grade 4, all students must develop the ability to:

- Plan and conduct simple investigations
- Employ simple equipment and tools to gather data and extend the senses
- Communicate about observations, investigations and explanations
- Review and ask questions about the observations and explanations of others
- Identify problems and potential technological/engineering solutions
- Understand the design process, role of troubleshooting

Grade 1: LIFE SCIENCE: Basic Needs of Living Things

- Living things survive only in environments that meet their needs.

Grade 1: PHYSICAL SCIENCE: Motion and Materials

- Properties of objects and materials can change.

Grade 2: PHYSICAL SCIENCE: Changes in Motion

- Forces change the motion of an object.

Grade 3:PHYSICAL SCIENCE: Matter and Forms of Energy

- All objects and substances in the natural world are composed of matter.
- Matter exists in different states, each of which has different properties.
- Heat, electrical energy, light, sound, and magnetic energy are forms of energy.

Grade 4: LIFE SCIENCE: Earth's Living History

- Changes in an organism's environment are sometimes beneficial to its survival and sometimes harmful.

Grade 5: PHYSICAL SCIENCE: Light, Sound, and Motion

- The amount of change in movement of an object is based on the mass of the object and the amount of force exerted.

Mathematics Standards:

- Represent and interpret data. CCSS.MATH.CONTENT.3.MD.B.4 Generate measurement data by measuring lengths using rulers marked with halves and fourths of an inch. Show the data by making a line plot, where the horizontal scale is marked off in appropriate units--whole numbers, halves, or quarters.
- Use place value understanding and properties of operations to perform multi-digit arithmetic. CCSS.MATH.CONTENT.3.NBT.A.2 Fluently add and subtract within 1000 using strategies and algorithms based on place value, properties of operations, and/or the relationship between addition and subtraction.
- Use place value understanding and properties of operations to perform multi-digit arithmetic. CCSS.MATH.CONTENT.3.NBT.A.2 Multiply one-digit whole numbers by multiples of 10 in the range 10-90 (e.g., 9 x 80, 5 x 60) using strategies based on place value and properties of operations.
- Represent and solve problems involving multiplication and division. CCSS.MATH.CONTENT.3.OA.A.1 Interpret products of whole numbers, e.g., interpret 5 x 7 as the total number of objects in 5 groups of 7 objects each.

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- Represent and solve problems involving multiplication and division. CCSS.MATH.CONTENT.3.OA.A.1 Use multiplication and division within 100 to solve word problems in situations involving equal groups, arrays, and measurement quantities, e.g., by using drawings and equations with a symbol for the unknown number to represent the problem.
- Multiply and divide within 100. CCSS.MATH.CONTENT.3.OA.C.7 Fluently multiply and divide within 100, using strategies such as the relationship between multiplication and division (e.g., knowing that 8 x 5 = 40, one knows 40 ÷ 5 = 8) or properties of operations. By the end of Grade 3, know from memory all products of two one-digit numbers.

Materials List:

Material	**Quantity per Team**	✓	**Quantity per Kit**	✓
Volcano Rising by Elizabeth Rausch	~		1	
Wooden Craft Sticks	4		50	
Masking Tape	1 foot		5 yards	
Straws	8		100 straws	
Foam Plate	1		15	
Cardboard	1		15	
Crayola Modeling Clay	1/8 stick		2 sticks	
Foil	3 inches		1 roll	
Lego Blocks	5		60	
Toothpicks	10		100	
Duct Tape	4 inches		1 roll	
Foam Cups	½ cup		10	
Clean Plastic Soda Bottle	~		1	
3% Hydrogen Peroxide	~		3 cups = 48 ounces	
Dry Yeast	~		6 packets (1 tablespoon)	
Warm Water	~		30 tablespoons	
Liquid Dish Soap	~		6 tablespoons	
Red Food Coloring	~		1 bottle	
Small Cup (reusable)	~		1	
Waterproof Plastic Structures (Be Creative)	~		4	
Aluminum Roasting/Baking Pan (cookie sheet)	~		1	

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Measuring Cup	~		1 (1/2 cup)	
Measuring Spoon	~		1 (1 tablespoon)	
Mixing Spoon (small)	~		1	
Warm Water	~		1 small bottle	
Sponge (for cleanup)	~		1	
Small Funnel	~		1	
Safety Goggles for Mixing Foam	~		1	
Cardstock	1 sheet		1 pack	
Post-it Notes **OR** Paper *(For individual brainstorming)*	15 Post-its **OR** 3 sheets paper		2 packs Post-its **OR** 25 sheets paper	
Paper *(For team design sketch)*	1 sheet		15 sheets	

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Activity 1

Introduction: 10 minutes

- Sit in a chair and gather the students on the floor around you so they can all see the book.
- Remind the students of the full scope of the Engineering Challenge (Activity 1, Activity 2, Activity 3, etc.)
- Introduce *Volcano Rising* by Elizabeth Rausch. Ask students to title a new entry in the STEM notebook (Entry #X, Date). Ask them to list everything they know about volcanoes. You can provide a list of words or phrases for the students to choose from if they need this level of support. Next, have them draw a line under their list, and turn to a partner. Ask them to read their list to their partner. After their partner reads their list, they should add items below the line they drew that they would like to also remember about volcanoes. Finally, at the bottom of their entry, ask the students to write a sentence summarizing what they know about volcanoes.

Pre-Reading: 10 minutes

- Introduce the Expectation Grid by placing it on the Document Camera or PowerPoint. Distribute a copy to each student (this can be glued into the STEM Notebook). Ask the students to make predictions about what they will learn about volcanoes in the book, *Volcano Rising*. Remind them that nonfiction books sometimes have headings that describe the topic. What might the headings be in this book, or what broad categories of volcanoes do they think they might learn about? Fill these in on the grid, and include any details that correspond with their predicted headings in smaller print or another color. Ask the students to fill in their personal grid as you complete the class grid. See the model included.

Read Aloud: 20 minutes

- Read the book aloud to the students. When their predicted topics come up in the book, point it out to the students, and ask them to raise their hands if they notice these connections on their own.
- After reading the book, ask the students to complete the Expectation Grid in their Notebooks, adding in any other details or facts they learned about volcanoes that they did not predict. Ask them to put a checkmark next to any of the facts they predicted that did appear in the book and circle any of the details that did not appear in the book.

Post Reading: 15 minutes

- Show the students the video about volcanoes. On large chart paper or a white board, create a Venn Diagram to compare the two “texts” (the book and the video). Students should write facts about volcanoes that they learned from the video, the book, or both on three different colored post-it notes and place them on the Venn Diagram. This can be done in partners. You can also create the post-it notes ahead of time if students will need more support writing the facts down. Students can then select the post-it notes they would like to place in the appropriate space on the diagram.

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- Have a discussion about the similarities and differences between the two texts (the book and the video). We can learn some of the same information from different sources, but it is presented in a different way. We can also learn different information by looking across a variety of different sources.

Wrap Up: 5 minutes

Review what was learned during today's session.

- Invite a retelling of the book by asking students to share what happened first, second, third, and so on in the story.
- Review the facts about volcanoes that were discussed.
- Remind the students that tomorrow they will learn more about the Engineering Design Challenge.

Activity 2

Introduction: 10 minutes

- Complete a picture walk through *Volcano Rising* and ask students what is happening throughout the story
- Ask students about facts that they learned about volcanoes (turn and talk or individual responses)
- Explain to students that the book will relate to the design challenge
    - "The story tells us about how volcanoes erupt and create new islands and more land. For our design challenge you will be thinking about how you could direct the flow of lava so it is creative and not destructive. You will hear more about this later."

Quick Write: 15 minutes

- For the *Quick Write*, provide students with one of the following prompts, and invite them to write their responses. Students can write or draw their responses, or a combination of both, depending on their abilities.
    - I learned _____ new facts about volcanoes today. They are: (list).
    - If I visited a volcano, I would look for _____.
    - Volcanoes are _____.
    - Students can write one sentence or five paragraphs in response to these prompts!

Application: 20 minutes

- Display slide 1 of the PowerPoint: Ask the students to share some ideas about what engineers do for their jobs.
- Slides 2 & 3: Continue the discussion about what engineers do for their jobs.
- Slides 4 & 5: Present the Design Challenge Problem.
    - Design Challenge Problem: Mount St. Helens is about to erupt. Your task is to create a structure that will save the surrounding buildings before the flowing lava puts the civilians in danger. You have around 15 minutes to

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complete the task and save the buildings from the lava flow.

- Slide 6: Present the Engineering Design Challenge:
    - Engineering Design Challenge: Your team's challenge is to create a structure that will change the flow of foam (lava) so that the flow does not touch the buildings.
- Slide 7: Explain or share the Design Goals.
    - Create a design that protects the building.
    - Must be built in time given.
    - Can only use materials your purchase and within limits given.
    - Have fun!!
- Slide 8: Introduce the resources/materials available.
    - Craft sticks, masking tape, duct tape, straws, foam plate, cardboard, foam cup, crayola modeling clay, foil, Lego blocks, and toothpicks
- Slide 9: Explain the design testing procedures.
    - Three groups will bring their designs to the testing tin where the houses are set up.
    - The facilitator will mix the reaction and advise students to step back and observe.
    - The designs will be evaluated based on the level of protection their design provided from the lava flow.
    - The groups will continue to be tested in groups of three until all groups have tested their design.
    - Place the houses in the tin spread apart in marked three areas. Have groups place their design where they determine would be the best spot to implement their design.
- Slide 10: Explain the Engineering Design Process.
- Slide 11: Have the students complete the "Ask" step of the Engineering Design Process.
    - Give students the Engineering Design Process Graphic Organizer STEM Challenge handout and the Volcano Rising: Engineering Design Process student handout.
    - Ask the students to notice that the word Ask is in one of the circles of the Engineering Design Process both on the PowerPoint and on the Volcano Rising: Engineering Design Process student handout.
    - Students should Ask themselves what materials they would like to use to create their structure to protect the building from the lava flow.
    - Students should write these materials on their STEM Challenge handout.
    - Walk around as the students complete the Ask step of the Engineering Design Process and query them about their ideas.
- Slide 11: Explain to the students that the next time they meet, they will spend time on the Imagine step in the Engineering Design Process. In fact, you can ask students to start imagining what their structure will look like when they are at home, and they can share their ideas with their families.

Wrap Up: 10 minutes

Review what was learned during today's session.

- Invite a retelling of the book by asking students to share what happened first, second, third, and so on in the story.

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- Review the facts about volcanoes that were discussed.
- Remind the students of the Engineering Design Challenge.
- Preview the next session by explaining to students that they will continue the Engineering Design Process so that they can imagine and plan to design and create their structure to protect the buildings from the lava flow.

Activity 3

Set-Up:

- Designate space for displaying and gathering available materials.
- Designate space for each team to collaborate and create their design ideas. Also, make sure all students will be able to see the presentation.
- Designate space for design testing. Make sure there is room for all students to observe.

Introduction: 5 minutes

- Remind the students that during the previous session they looked through and discussed the book *Volcano Rising* by Elizabeth Rausch and were presented with a Design Challenge Problem and Engineering Design Challenge. Generate a discussion about the Design Challenge Problem and Engineering Design Challenge. Remind students of the main idea of the book and how it relates to the design challenge.

Engineering Design Process, Imagine: 10 minutes

- Display slide 11 of the PowerPoint:
    - Ask the students to notice that the word Imagine is in one of the circles of the Engineering Design Process both on the PowerPoint and the Volcano Rising: Engineering Design Process student handout.
    - Students should Imagine what their structure will look like to protect the building from the lava flow.
    - Students should draw a picture or write a description of their structure on their STEM Challenge handout.
    - Walk around as the students complete the Imagine step of the Engineering Design Process.
    - Ask the students to share their ideas with their team.
    - Walk around as the students share their ideas with their teammates. Make sure that each student is given ample time to share his or her ideas. Students get excited about wanting to create a structure to protect the buildings from the lava flow and often rush through the sharing process. Remind students that the sharing process is extremely important as engineers often alter their designs based on ideas shared during the brainstorming process.

Engineering Design Process, Plan: 10 minutes

- Display slide 11 of the PowerPoint:

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- Ask the students to notice that the word Plan is in one of the circles of the Engineering Design Process both on the PowerPoint and the Volcano Rising: Engineering Design Process student handout.
- Students should Plan as a team what their structure will look like.
- Students can use teammates' ideas or a combination of the teams' ideas, but remind them that they must create one structure together as a team!
- Students should draw a picture or write a description of their structure to protect the building from the lava flow on their STEM Challenge handout.
- Walk around as the students complete the Plan step of the Engineering Design Process.
- Make sure all students are contributing to the planning process. Often the dominant students expect the other students to use his or her ideas. Remind students that coming to a team consensus is important as engineers are often expected to plan with a group of people.
- Ask the students probing questions about their structure:
  - How did you combine your individual design ideas?
  - Why did you choose that design?
  - How did you create the idea for this design?
  - What are your reasons for selecting the material for your structure?
- Before allowing teams to create their structure to protect the buildings from the lava flow, require them to gain approval of their sketch of the team's prototype design idea. You can write "Approved" beside the sketch on a student's paper or hand them a note card with "approved" written on it. A colored note card works nicely as you can easily see if a team has the note card on their desk or table before they begin to work with the materials.

Buying Time!: 15 minutes

- Display slide 8: Students work as a team to decide what materials they want to purchase to create their structure to protect the building from the lava flow. The materials are on slide 8 of the PowerPoint and on the Volcano Rising: Buying Time! handout. Students should use the table in the student handout to record the number of each item they want to purchase, the cost associated with each item, and the total cost of all items.
- Walk around the room as the students discuss the materials they would like to purchase.
- Once a team is ready to purchase their materials, have them tell you the cost of the materials they would like to purchase and the change they should receive.

Engineering Design Process, Create: 20 minutes

- Slide 11: Teams create their structure to protect the buildings from the lava flow
  - Ask the students to notice that the word Create is in one of the circles of the Engineering Design Process both on the PowerPoint and the Volcano Rising: Engineering Design Process student handout.
  - Students should draw a picture on the STEM Challenge handout of the structure they plan to create.
  - As the students are creating their structure, walk around the room and ask

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them probing questions about their design. For example:

- Why did you choose those materials for the structure?
- Will the structure be strong enough to resist the lava flow?
- Will the structure be tall enough to resist the lava flow?
- Will the structure be wide enough to resist the lava flow?

Wrap Up: 5 minutes

- Ask students to place their handouts and materials in a safe location and to clean up their area.
- Distribute a parent letter to each student.

Activity 4

Introduction: 10 minutes

- Show the students the book, *Volcano Rising,* by Elizabeth Rausch, and ask them to raise their hands and offer a one-sentence summary of the book. Invite as many one-sentence summaries as time allows. Alternatively, ask the students to turn to a partner and tell a one-sentence summary of the book. Remind students that they are working on designing and creating a structure to protect the buildings from the lava flow.
- Help teams of students locate their handouts and materials.
- Remind the students that during the previous session they created a structure that can divert the flow of lava (foam) away from the buildings.
- Today, students are going to test their structure.

Lava Flow Protection Structure Testing: 30 minutes

- Before testing, set up the testing area by placing four buildings on a cookie sheet--one building toward each corner of the cookie sheet--about six inches apart. The foam will be generated in the middle and spread outwards so that multiple structures can be tested at the same time. Gather the materials needed to make the foam.
- Four teams will test their prototype structures while other teams observe. Four teams will bring their designs to the testing tin where the buildings are set up and place them on the cookie sheet. They will then watch as the facilitator mixes the ingredients for the lava foam (see instructions below). The facilitator will mix the reaction and advise students to step back and observe. The designs will be evaluated based on the level of protection their design provided from the lava flow. A design is successful if it protects the house entirely from the lava. Designs can also be evaluated based on the relation of which design was most successful of the four being tested at the same time. The groups will continue to be tested in groups of four until all groups have tested their design.

Lava Foam Recipe and Instructions:

1) clean and empty 16 ounce plastic soda bottle
2) ½ cup of 3% hydrogen peroxide
3) 8 drops of red/orange food coloring

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4) 1 tablespoon of liquid dishwashing soap
5) 1 small plastic cup
6) 1 package of active dry yeast (1 tablespoon)

Instructions for Lava Foam:

1) Hydrogen peroxide can irritate skin and eyes, so put on safety goggles and have an adult carefully pour the hydrogen peroxide into the bottle. Pour one-half cup of hydrogen peroxide into the empty and clean 16 ounce plastic soda bottle.
2) Add 8 drops of your favorite food coloring to the bottle.
3) Add about 1 tablespoon of liquid dish soap into the bottle and swish the bottle around to mix the ingredients.
4) In a separate small cup, combine the warm water and yeast together and mix for about 30 seconds.
5) Now the adventure starts! Pour the yeast water mixture into the bottle (a funnel helps here) and watch the foaminess begin!

Explanation for the foam reaction:

Foam is awesome! The foam you made is special because each tiny foam bubble is filled with oxygen. The yeast acted as a catalyst (a helper) to remove one of the oxygen atoms from the hydrogen peroxide molecules. Since it did this very fast, it created lots and lots of bubbles. Did you notice the bottle got warm? Your experiment created a reaction called an Exothermic Reaction - that means it not only created foam, it also created heat! The foam produced is just water, soap, and oxygen so you can clean it up with a sponge and pour any extra liquid left in the bottle down the drain.

Reflection: 10 minutes

- Slide 12: Ask students to discuss with their team:
    - What do you like best about your structure to protect the building from the lava flow?
    - What would you change about your structure?
    - What aspects of other team designs stood out to you?
    - Did other designs give you any ideas for ways to improve your design?
    - What modifications will you make to redesign your structure?
    - How did the materials affect the ability of your structure to divert the lava flow and protect the buildings?
- Students should complete the Volcano Rising: Test and Improve Your Device handout.
- If time permits, ask some students to share their ideas with the entire class.
- Ask the students if they have any ideas as to what type of engineer might design and create lava flow protection structures.

Wrap Up: 5 minutes

- Ask students to place their handouts and materials in a safe location and clean up their area.
- Distribute the parent letter.

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Activity 5

Introduction: 5 minutes

- Last time we tested our structures.
- Today we are going to redesign our structures and wrap up the STEM challenge.

Structure Redesign and Construction: 30 minutes

- Slide 12:
    - Students should draw a picture on the STEM Challenge handout of the improved structure they plan to create.
    - Students use what they have learned testing their designs to modify and improve their structure to protect the buildings from the lava flow.
    - As the students are working on their new designs, walk around the room and ask them probing questions about their redesign. For example:
        - How well did your first design work?
        - Why are you making that change?

Redesigned Structure Testing: 20 minutes

- Four teams at a time will test their prototype structures while other teams observe.

Wrap Up: 20-30 minutes

- Ask students to place their handouts and materials in a safe location and clean up their area.
- Discuss text-to-self, text-to-text and text-to-world connections with the students. Put the Text Connections handout on the overhead or Elmo machine so all students can see it and explain each type of connection.
- If time allows, read the story*, Volcano Rising,* again. As you read, ask the students to make text-to-self, text-to-text or text-to-world connections between what they hear in the story and the STEM challenge. Ask them to keep track of their connections using tally marks for each connection on a blank copy of the handout, which can be pasted into the STEM journal as an additional entry.
- Stop periodically throughout the story to share your own connections as a model, then invite students to share their connections. Remind them of the importance of using “textual evidence” to make their connections. Ask, “What sentence or picture in the story helped you make that connection?”.
- (Optional Writing Activity) Ask the students to write a one paragraph summary of their connections to the book and the STEM challenge in their STEM notebooks.
- Slide 13: Conclude by discussing the following questions as post-activity surveys are distributed.
    - What ideas do you have for engineering a better world?
    - How can you turn ideas into reality?
- Allow time for students to complete their post-activity survey.
- Distribute the parent letter to each student.

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