AMP IT UP

Advanced Manufacturing & Prototyping Integrated to Unlock Potential

EARTH SCIENCE

Experimental Design

MOLTEN MADNESS

Lava Challenge

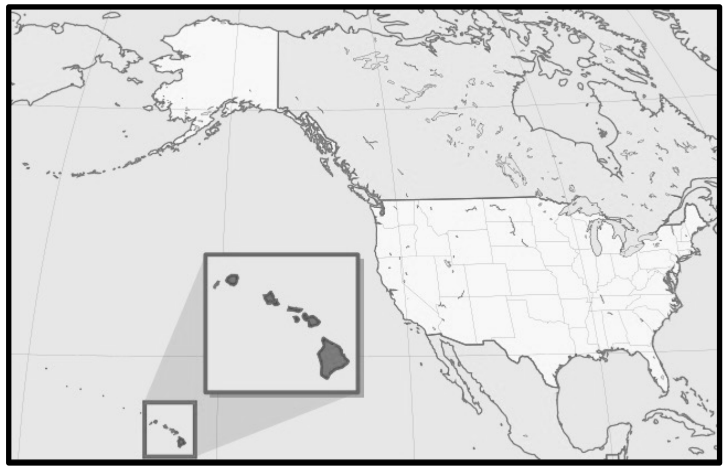
Fall 2018

6EDS

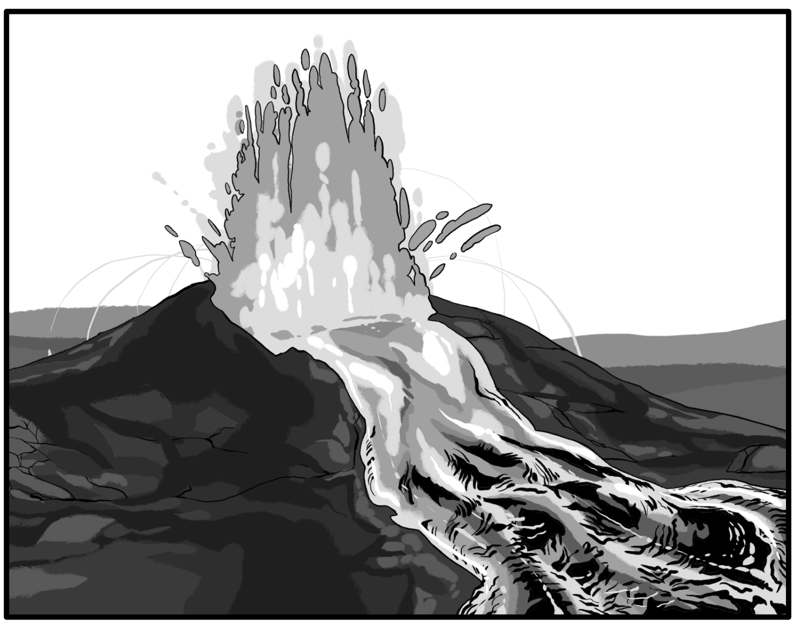
SECTION 1 – THE LAVA FLOW CHALLENGE

1.1 INTRODUCTION

A volcanic eruption is an amazing display of the power of nature. Streams of red-hot lava flowing over land make spectacular photographs. However, volcanic eruptions are life and property threatening situations.



The Hawaiian Islands are volcanic islands in the Pacific Ocean. They are made of volcanic material laid down from repeated eruptions. Some of these volcanoes are still active today. Towns near volcanoes usually develop emergency plans to evacuate, or move, people out of the area safely and quickly if a volcano erupts. Towns usually develop one plan for when a quick evacuation is needed and other plans for slower evacuations. The speed of the lava flow determines which plan the town follows. So, the people of the town need a clear procedure for measuring lava flow. In this challenge, you will help a town council determine the best way to measure the time it takes lava to flow on land. You will work as part of a team.



Watch ***CNN Lava*** video #1

KEY TERMS

Model: A model of a real-life situation can be used to test important aspects of a phenomenon under investigation. It can be used to generate predictions, explanations, and solutions. That said, models are limited in what they can represent about the real-life situation.

1.2 MODELING LAVA FLOW

Before your team can help the town develop good evacuation plans, the town council must have confidence that you know how to measure how much time it takes lava to flow accurately. Your group will have to send them the procedure, along with evidence that your procedure is accurate. Your group will demonstrate that you can measure the time accurately by using a **model** of the lava flow. We use a model because:

1. We cannot test the real-life lava flow because we do not have an erupting volcano in or near the classroom.
2. If we wait for the town's volcano to erupt to measure its lava flow, the eruption might hurt people and damage the town. We must make plans before the next eruption.

Scientists frequently use models in place of actual events, processes, and situations. This allows them to safely investigate dangerous or difficult events and understand how things work.

Discuss this question as a class:

1. What are some other models that scientists use to investigate real-life situations?

SECTION 2 – INVESTIGATE LAVA FLOW

2.1 PLAN AN INVESTIGATION

Because you cannot use actual lava, you are going to make a model of lava flow. You will use dish soap and a plastic plate to simulate lava flowing across a landscape. You might say that this model is not realistic because dish soap is not as hot as lava. That is true, but your model is not investigating the temperature of lava. You are measuring the time it takes for lava to flow, and dish soap flows very much like some types of lava. This makes the soap and plastic plate a good set of materials for modeling lava flow.

The town sits a few miles away from the volcano. It is important to realize that the evacuation plan depends mostly on the time it takes lava to get from the base of the volcano to the town you see here. Your model should factor in the slope in the landscape.

Procedure:

1. Spend 5-6 minutes discussing and creating a procedure for measuring the time it takes for lava to flow with your group.
    a. You can use the materials listed here to design and follow a procedure to determine how much time it takes the lava (soap) to flow across the surface of the plate. Additionally, you must complete at least six trials during your investigation, and record the data after each trial.
2. Write your procedure on your *Investigation Sheet 1*.
3. Raise your hand for your teacher come by to make sure that you have recorded your procedure and are ready to begin your investigation.

Materials

- Plastic Plate
- Model Lava (dish soap)
- Small Paper Cup (lava flow)
- Sharpie marker
- Stopwatch or timer
- Ruler
- Paper Towels
- *Investigation Sheet 1*

2.2 CARRY OUT YOUR INVESTIGATION

You will have ten minutes to run your procedure. You have everything you need to model the flow of lava. You will measure time in your procedure, you should measure your time in seconds. Round fractions of seconds to the nearest whole second (ex: 3.51 seconds rounds to 4 seconds).

Procedure:

1. Follow the procedure that your group created for at least six trials.
2. Record the result of each trial on your *Investigation Sheet 1*.

Recording results allows scientists to accurately report their findings. The data you record will help others understand your group's work. Be prepared to share your results with your class.

2.3 COMMUNICATE YOUR RESULTS

Now, each group will report to the class the results of their investigation. Your teacher will record the outcomes on a graph known as a **histogram**, or **line plot**. Review Box 1 to learn more about histograms. For each result measured during the investigations, we will place an "X" on the graph.

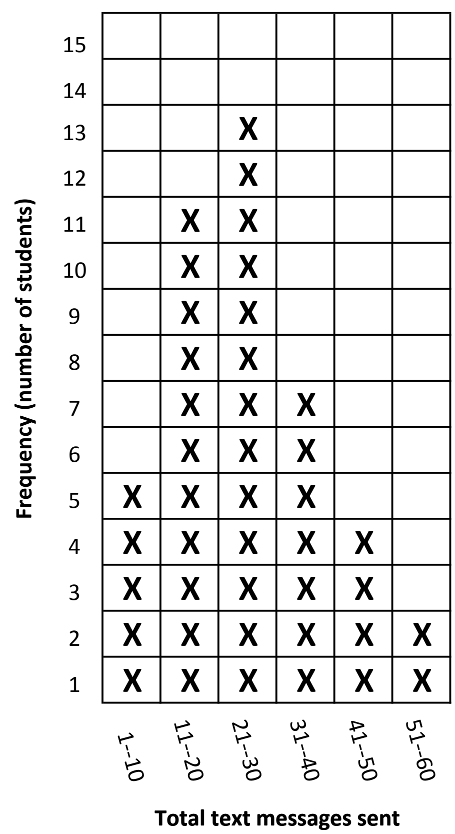
Procedure:

1. As each group reports their results, chart those trials by placing an "X" on the graph for every data point on your *Results Graph 1*.
2. Your class will analyze the graph to see if your team has demonstrated that they can measure lava flow well.

Box 1: Graphing a Histogram

A histogram (sometimes called a *line plot*) is a type of graph that shows the **frequency** (number of times) that a specific outcome occurred.

For instance, suppose you wanted to see the number of text messages that the students in your class sent last week. You could count the number of students that the sent 0-10 messages, the number of students that sent 11-20 messages, etc. If four students sent 0-10 messages, then the frequency of 0-10 messages is four. A hypothetical graph of these data is on the right. *Text messages sent* is on the X-axis and *Frequency (number of students)* is on the Y-axis. How many students sent between 31-40 text messages?



2.4 ANALYZE THE DATA

Procedure:

1. Look at the histogram that was created from the class data.
2. Answer the discussion questions below as a class. Have your written procedure available as you answer the questions.

Discuss these questions as a class:

1. Did your group have any difficulties (mistakes, spills, etc.) while following your procedure? Describe each one.
2. How similar are the results of different groups? Why?
3. What did the distribution, or spread, of data on the histogram look like? What do you think this says about how reliable the class's data is?
4. What could the class do to get results that are more similar (consistent)?
5. Do you think the Town Council that hired you to develop a procedure measuring lava flow for towns near active volcanoes will trust your results?

3. Discuss how your answers may help you to complete the Lava Flow Challenge better.

SECTION 3 – REDESIGN YOUR INVESTIGATION

3.1 REFLECT ON FIRST INVESTIGATION

Your class probably did not agree on how long it takes the dish soap to flow. Your histogram may have shown that your class cannot produce results that can be trusted. Now, you will see if you can find a way to make the results more consistent across groups.

Think about what went wrong. You were all trying to answer the same question. You all measured the time it took dish soap to flow across a plastic plate. You all used the same unit of measurement, which was time. You all had the same materials. But every group used a different procedure. You all collected data in different ways. No wonder the results were so different.

3.2 ADD TO YOUR UNDERSTANDING: TRUSTWORTHY INVESTIGATIONS

Scientific and engineering investigations happen for many different reasons. Some help to explain new events or processes. Some test a theory or model, while others compare different solutions to see which best solves a problem. When carrying out investigations, scientists and engineers use <u>consistent procedures</u> in order to get trustworthy data. **Consistency** refers to using the same procedure repeatedly to collect data. In order to make sure trustworthy data is collected, they develop and use a consistent procedure for all trials of their investigation.

KEY TERMS

Consistency: using the same procedure repeatedly to collect data

Scientists and engineers do not write their procedure only once and then stop. Instead, they refine their procedure to make it more consistent. After collecting data, scientists and engineers might consider ways to improve their procedure for their next experiment. Then, they collect data again using the revised procedure to see if the data results are more consistent.

Scientists also share their procedure and data with other scientists who then provide feedback. This collaboration helps reveal any patterns and relationships within the data along with any potential inconsistencies in the procedure. The data can be better communicated through graphing and analysis, which is how you interpreted patterns in the class histogram on *Results Graph 1.*

You probably saw a wide spread of data in the histogram. This is called **variation**. It is important to use the same procedure every time you test or measure something. Your results will then be consistent, they will probably be repeatable and it will likely reduce the variation in the data collected.

The class will decide on a standardized procedure that everyone will use to measure lava flow. A standardized procedure means that everyone will do each step the same way. That way, you will be sure that the results obtained by different people or groups can be compared.

Creating a good procedure requires identifying the steps in the procedure very specifically, so it can be run the same way each time. It also requires identifying possible sources of **error**. This tells someone following a procedure how to do it to get repeatable results and what to be careful about as they are running it. When procedural differences are unintentional then we say that they add error to the data. Scientists try to remove as much error from their data as possible.

KEY TERMS

Variation: a change or difference in condition

Error: a measure of the estimated difference between the observed or calculated value of a quantity and its true value

Procedure:

1. Your teacher will make a list of the procedural differences you noticed during your first investigation.
2. As a class, discuss changes that could make your procedure more consistent and identify possible sources of error.
3. As a class, revise the procedure to decide which procedural details that all groups should follow. Your teacher will record and display the new procedure as the class designs it.
4. After the class has decided on the procedure, each group should review and discuss the new procedure.
5. Each group member should record the new procedure on *Investigation Sheet 2*.
6. Raise your hand for your teacher to come by to make sure that you have recorded your procedure and are ready to run the investigation again.

Discuss these questions as a class:

1. What are three or four key differences between your previous procedure and the new class procedure?
2. What are you now controlling better in the new procedure?
3. What effect do you think this new procedure will have on the range of results across groups?

SECTION 4 – INVESTIGATE LAVA FLOW WITH NEW PROCEDURE

4.1 CARRY OUT YOUR NEW INVESTIGATION

Now that you have a new standard procedure, your class should be able to produce more reliable results. Your class will collect another set of data and produce a new histogram.

Procedure:

1. Follow your new procedure using the materials listed to complete 6 trials.
2. Record your results on *Investigation Sheet 2,* which you used to write your revised procedure.

Materials

- Plastic Plate
- Model Lava (dish soap)
- Small Paper Cup (lava flow)
- Sharpie Marker
- Stopwatch or timer
- Ruler
- Paper Towels
- *Investigation Sheet 2*

Be prepared to share your results with your class and teacher. You will have 10 to 15 minutes to perform your investigation and collect your data.

4.2 COMMUNICATE YOUR RESULTS

Procedure:

1. Once all groups finish collecting data, each group will share their results.
2. Each student will plot the results on his or her *Results Graph 2* as the teacher creates another histogram, too. Each group should report any problems they had completing the procedure (e.g., mistakes, spills, or other uncontrolled variables).

4.3 ANALYZE THE DATA

After your class creates the histogram, think about and discuss as a class how the new, more specific procedure demonstrates the class's ability to measure the time lava flow.

Discuss these questions as a class:

1. Did your group have any difficulties (mistakes, spills, etc.) while following your procedure? Describe each one.
2. What did the distribution of data on the histogram look like?
3. What do you think this says about how reliable the class's data is?
4. What could the class do to get results that are more consistent?
5. Do you think the Town Council that hired you to develop a procedure measuring lava flow for towns near active volcanoes will trust your results?

One more time?

You might find that the range of results is still too large for you to trust. If so, return to your procedure. See if there are ways to standardize and control the procedure even more. Discuss how to better improve the steps and process, and record a new procedure. Then, follow this new procedure with 6 trials. Afterward, as a class, plot these new results on another histogram to see if you are getting more reliable data because of a better procedure.

4.4 ANSWER THE CHALLENGE

Science and engineering require using well-designed, consistent procedures for measuring and collecting data. To do this, scientists and engineers carefully record their procedure so that they and others can repeat the procedure and verify measurements.

In the first investigation, some groups might have let the angle of the plate change between trials. This caused the slope, or steepness, of the surface to change between each trial. This would affect how long it takes the lava to flow and therefore add error to the time data. Plate or surface angle is an example of a **variable**. A variable is any part of the procedure that could change.

In the second investigation, every group should have used the same plate angle. Because each group consistently used the same angle for all trials, the plate angle became a **controlled variable**. A controlled variable is a variable that stays the same each time the procedure is followed. Controlling a variable usually reduces error. The data should have been more accurate, and thus more clustered together on the histogram across a smaller range of time.

KEY TERMS

Variable: any part of the procedure that could change

Controlled variable: one element that is not change throughout an experiment

By developing a consistent procedure for everyone in the class to use, your results also became more consistent. The more consistent your class results are, the more your procedure will be trusted. Your class may have needed a third round of revisions to get a consistent procedure. Whether it was two or three rounds, you should better understand how important good procedures are. You planned an investigation with your classmates where you identified:

- variables and controls
- tools needed to gather data
- measurements to be recorded
- data to help people make decisions about a problem or challenge.

Your team has demonstrated that it can accurately and repeatedly measure lava flow. The Town Council of Hilo (a neighboring town) heard about your success and they are interested in hiring you for a similar job. Write them a letter and convince them they should hire you for their job. In your letter detail what you have learned about the importance of writing and following clear procedures and why the results from your last investigation were better than your first.

Procedure:

1. Complete the *Town Council Letter* student sheet and explain what you have learned about the importance of writing and following clear procedures.

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This curriculum is produced by Advanced Manufacturing & Prototyping Integrated to Unlock Potential (AMP-IT-UP) supported by National Science Foundation Award #1238089 through Georgia Institute of Technology's Center for Education Integrating Science, Mathematics, and Computing (CEISMC).

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