

 **EDUCATOR**

# **INVESTIGATION 4: FIRE LAB DATA ANALYSIS**

**CASE STUDY OF SCIENCE AND ENGINEERING**

SCIENTISTS ASK WHY. ENGINEERS ASK HOW.



**AGE GROUP**  
Middle School



**CATEGORY**  
Fire Forensics



**COMPLETION TIME**  
1 - 2 Class Periods

Enduring understanding: To investigate a fire, we must understand ignition and combustion principles. To solve a case, we must understand how to build a claim supported by evidence and reason.

## INVESTIGATION 4: FIRE LAB DATA ANALYSIS

Fire investigators must understand the effect of ventilation on a fire and what happens when a door or window is left open during a fire.

### Exploration: What does the fire lab data tell us about a fire?

Students look at oxygen concentrations from ignition in the fire lab during a controlled house fire where the variable being tested is ventilation – one data set is from a burn where the door was left open and one data set is from a burn with the door closed. Students can also explore data sets indicating temperature and pressure from each burn.

### The TESTABLE question guiding our investigations is:

- What is the impact of ventilation on a house fire?

### Essential knowledge and skills

We will look for students to understand:

- Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-PS1-4)

We will look for students to be able to:

- Analyze and interpret data to determine similarities and differences in findings. (MS-PS1-2)
- Construct, use, and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon. (MS-PS3-5)

### ASSESSMENT: This understanding looks like

- Students can make a claim supported by evidence collected through data sets from vented and unvented burns collected in the fire lab.
- Students can apply knowledge/elaborate reasons that it is important for fire fighters and fire investigators to understand the impact of ventilation on a fire.

## SUMMARY OF LAB

Using the data from two burns in the fire science lab, students will make conclusions about the impact of ventilation on a fire. Students will present their ideas about why this understanding is critical for both fire fighters and the women and men investigating the fire's origin and cause.

## eXPLORING THE ISSUE

### Background information

Organizing and understanding data is a critical skill for students in the 21st century. It is also a critical skill for fire researchers. Knowing how to interpret data from the fire lab helps prepare fire fighters to be more safe attacking fires and for fire investigators to read the evidence left behind in a burn scene.

The data set included is from the 2017 Firefighter Safety Research Institute (FSRI) tests on vented compared to unvented burns in a single-story home. This data was collected using highly sensitive sensors placed around the structure from the floor to the ceiling every four inches up from the floor. The tests were controlled, down to the exact placement and weight of the furniture and furnishings in the structure. The only variable was the front door – open (vented) or closed (unvented).

The question guiding the FSRI team of researchers and engineers was, “What is the impact of ventilation on a house fire?”

When a fire occurs in a home, and all the doors and windows are closed, the fire will extinguish on its own as it runs out of a fresh supply of oxygen. We know this because of our understanding of the fire triangle. (see section 1 of the Investigator's Academy and Classroom Investigation 1: Fire Triangle)

But, when people are home and escape the fire, they exit the structure often leaving the door or window open behind them. Or, a firefighter will enter a home to fight the fire and will open a window or door. The effect of ventilation on a fire is important for all of us to understand. When a door or window is opened, the fire receives a supply of fresh oxygen that can keep the fire going, or lead to flashover, a dangerous phenomenon where every surface in a room ignites in flames.

The data set included in this section of the Fire Forensics: Claims and Evidence module is intended to give students the opportunity to read the data and see the evidence collected in the FSRI tests that support the claim that ventilated fires are more dangerous and damaging.

### Three of the variables in this fire lab investigation are:

1. **Oxygen levels.** This is measured as percentages. Our atmosphere is 21% oxygen.
2. **Air pressure.** This is measured as units of pressure (Pascals) written as Pa.
3. **Temperature.** This is measured in degrees Celsius. The average human body temperature is 98.6 degrees Fahrenheit, which is 37 degrees Celsius. The average room temperature is 70 degrees Fahrenheit, which is 21.11 degrees Celsius.

Why spend an entire month doing repeated burns to test one question? Why is this an important question for fire fighters and fire investigators to know the answer to?

## HELPFUL TERMS AND DEFINITIONS

**Venting.** The escape of smoke and heat through openings in a building.

**Pressure.** High pressure to low pressure.

**Gas levels.** Atmospheric oxygen is 21%. A ventilated fire will draw in fresh air with a supply of oxygen to the fire, while an unventilated fire will consume all of the oxygen in the room and, from our understanding of the fire triangle, when there is no oxygen available, the fire will extinguish. It is important to understand the effect of ventilation on the oxygen concentrations inside a structure.

**Temperature.** Hot air rises. High temp flows to low temp

**Flashover.** All of the gases auto ignite from the heat in the room pyrolyzing the surfaces in the room.

**Velocity.** Positive is fire gases exiting the house, negative numbers indicate air is entering the house.

**Sensor placement.** The sensors are meticulously placed at consistent heights around the structures in the fire lab. They measure pressure, temperature, and gas concentrations including oxygen.

## MATERIALS

(one set per group of students or one set for teacher's demonstration)

- ☐ Open or Closed Door student reading
- ☐ Data sets – oxygen, temperature, air pressure for both vented and non-vented fires (download)
- ☐ Markers/flip chart page
- ☐ Review Live Burn Video

## ROLES



### THE STUFF SUPERVISOR

Gathers and cleans up materials



### THE EXPERIMENT EXEC

Runs the experiment



### THE DIRECTOR OF DOCUMENTS

Reads the procedure to the group and helps the group members with data collection

## PROCEDURE - EDUCATOR

### ENGAGE

#### WHAT EDUCATOR DOES

1. Introduce the question guiding the FSRI data collection: “What is the impact of ventilation on a house fire?” or, what happens when a door is left open as a fire is occurring?
2. Students read introduction in Student Reading, “Open or Closed Door”.
3. Share answers as a class and discuss new vocabulary.

#### WHAT STUDENTS DO

1. Make predictions based on learning from Investigators Academy, background knowledge, or prior experiences. “I think....because....”
2. Read “Open or Closed Door” in Student Pages and answer questions, highlight new vocabulary.
3. Share answers as a class and discuss new vocabulary.

### EXPLORE

#### WHAT EDUCATOR DOES

Divide class into groups – 1 data set per group, 2-3 students per group.  
Hand out data for Round 1 with Timeline for unvented fire.

1. Each group works with one variable (oxygen, pressure, temperature) in two rounds.

Round 1: unvented (door closed)

Round 2: vented (door open)

#### ROUND 1:

Each group will study their graph on UNVENTED data and write two claims about the graph

- a. What can you say about oxygen levels in an unvented fire?
- b. What events in the fire happen when there is a change in the oxygen levels?

#### WHAT STUDENTS DO

Study graphs.

- What do the different colors mean?
- Where are the big changes (peaks and valleys)?
- What is happening in the fire when the big changes occur?
- Where is the line steady/flat?
- What is happening in the fire when the line is flat?

Write two claims about your graph.

What is the evidence to support your claim?

- What specific data from the graph supports the statement you wrote?
- Write a complete sentence stating why the claim you made is true.

## PROCEDURE - EDUCATOR

### EXPLAIN

#### WHAT EDUCATOR DOES

Each group share their claims as a class.  
Ask each group, "What is the evidence to support your claim?"

1. Does everyone agree with their claims?
2. Is there anything you would add?
3. What questions do you have?

#### WHAT STUDENTS DO

Presenter in group shares claims and evidence from the graph to support the claim.

Class responds with:

- a. Does everyone agree with their claims?
- b. Is there anything you would add?
- c. What questions do you have?

### EXPLORE

#### WHAT EDUCATOR DOES

##### ROUND 2:

Hand out data for Round 2 with Timeline for vented fire.  
Each group will study their graph on VENTED data and write two claims about the graph.

- a. What can you say about oxygen levels in a vented fire?
- b. What events in the fire happen when there is a change in the oxygen, temperature, air pressure levels?
- c. What do these graphs teach you about an open vs a closed door?
- d. Write a sentence summarizing what you think after looking at these two graphs.

##### A. Each group share their claims as a class.

Ask each group, "What is the evidence to support your claim?"

- a. Does everyone agree with their claims?
- b. Is there anything you would add?
- c. What questions do you have?

B. After all groups share, compare oxygen, temperature, and air pressure.

#### WHAT STUDENTS DO

Study graphs.

- What do the different colors mean?
- Where are the big changes (peaks and valleys)?
- What is happening in the fire when the big changes occur?
- Where is the line steady/flat?
- What is happening in the fire when the line is flat?

Write two claims about your graph.

What is the evidence to support your claim?

- What specific data from the graph supports the statement you wrote?
- Write a complete sentence stating why the claim you made is true.

## PROCEDURE - EDUCATOR

### EXPLORE CONT.

#### WHAT EDUCATOR DOES CONT.

What claims can we make about fire in a vented (open-door) situation vs a fire in an unvented (closed-door) situation?  
What is your evidence?

### EXPLAIN

#### WHAT EDUCATOR DOES

A. Each group share their claims as a class.

Ask each group, "What is the evidence to support your claim?":

- Does everyone agree with their claims?
- Is there anything you would add?
- What questions do you have?

B. After all groups share, compare oxygen, temperature, and air pressure.

What claims can we make about fire in a vented (open-door) situation vs a fire in an unvented (closed-door) situation?  
What is your evidence?

#### WHAT STUDENTS DO

Presenter in group shares:

- Claims and evidence from the vented (open-door) graph to support the claim
- Comparisons of the open and closed-door graphs.

Class responds with:

- Does everyone agree with their claims?
- Is there anything you would add?
- What questions do you have?

### EXPLORE/EXPLAIN

#### WHAT EDUCATOR DOES

Re-group students so that each single variable group (oxygen, pressure, temperature) is represented in a larger group. For example, put an oxygen group together with a pressure group together with a temperature group.

In these bigger groups, ask students to write two claims about vented vs unvented fires based on the data in the three data sets.

Share out to whole group and compare variables.

#### WHAT STUDENTS DO

Join two other groups so that all three variables are represented (oxygen, pressure, temperature).

What claim can your group make about a vented vs unvented fire?

Write two claims about vented vs unvented fires based on the evidence in all three data sets (oxygen, pressure, temperature).

## PROCEDURE - EDUCATOR

### ELABORATE

#### WHAT EDUCATOR DOES

Why is this important for fire fighters?  
Why is this important for fire investigators?

As a fire investigator, what is the benefit of knowing if a fire was vented or not vented? What do you think the fire scene looks like after a vented fire? After a fire that was not vented?

#### WHAT STUDENTS DO

Think – Pair – Share ideas on how this applies to fire fighting and fire investigation.

As a fire investigator, what is the benefit of knowing if a fire was vented or not vented?  
What do you think the fire scene looks like after a vented fire?  
After a fire that was not vented?

### EVALUATE

#### WHAT EDUCATOR DOES

Using the C/E/R rubric, assess quality and accuracy of responses and provide feedback to students.

#### WHAT STUDENTS DO

Question: What is the effect on ventilation on a fire?

Based on our observations of the data collected in the fire lab, what can we claim about the impact of an open door on a fire?  
How does ventilation effect oxygen levels, temperature in the house, and air pressure?

Work referenced: McLaughlin, Cheryl A. (2013, November). Engaging middle school students in the analysis and interpretation of real-world data. Science Scope, (37)3. Retrieved from: <http://www.naturalinquirer.org/UserFiles/File/McLaughlin%20Reprint.pdf>