

Ghost Balloon

STEM Lab

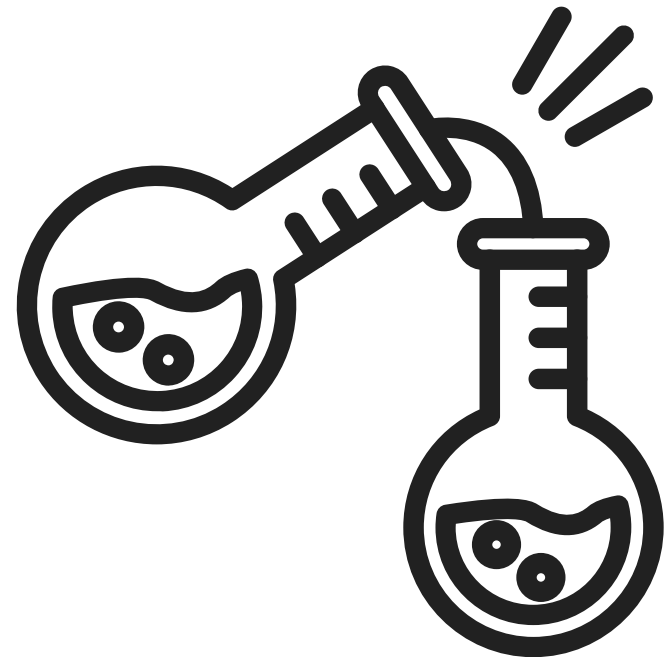
Scientific Method • Variables • Data & Graphing



Classroom-Ready



Data tables + bar graph templates included



Teach With
Fergy

Ghost Balloon STEM Investigation

Teachers Reference:

Purpose

Use an engaging gas-generation challenge to teach engineering design, variables and controls, data collection, graphing, and evidence-based claims. Teams design a safe CO₂-capture device to inflate a balloon and lift a lightweight 'pumpkin puck' to a target height efficiently.

Learning Objectives

- Plan and carry out a controlled engineering test with clear independent, dependent, and controlled variables.
- Collect sufficient data (replicates), compute averages and simple rates, and compare across conditions to optimize a design.
- Graph performance vs. design variable and construct evidence-based claims.
- Explain how reaction amounts, gas production, seals, and mass affect lift.

Safety

- Wear safety goggles at all times. Do not taste materials.
- Use 3% household hydrogen peroxide only, in small amounts, or substitute baking soda + vinegar.
- Do not tightly seal gases in rigid containers; the balloon is the pressure relief device.
- Keep faces away from bottle openings; clean spills immediately; wash hands after the lab.

Materials

- 500 mL plastic bottle with cap (1 per group).
- White balloon ('ghost') (1 per group).
- Baking soda packets (0.5 tbsp per packet) OR 3% hydrogen peroxide (15 mL portions) with dry yeast (½ tsp).
- Vinegar cups (60 mL portions) if using baking soda route; dish soap (optional, for foam capture).
- Funnels or paper funnels; measuring spoons; graduated cup for mL.
- Masking tape, permanent marker, ruler/tape measure, string, scissors, tape.
- Data sheets (included), clipboards, pencils.

Background Science for the Teacher

- Gas Generation and Lift:** CO₂ produced by a reaction inflates a balloon. The volume of gas depends on reactant amounts and reaction completion; sealing leaks increases usable gas for lift.
- Mass, Force, and Pressure:** The balloon exerts an upward force as it inflates and displaces air; a lighter puck and lower friction on the guide string increase achievable height.
- Stoichiometry & Limiting Reagent (qualitative):** Increasing one reactant only helps until the other becomes limiting; excess beyond the limiting point does not improve lift and can slow mixing.
- Systems Thinking:** Performance depends on reaction rates, leak prevention (seal quality), balloon size/elasticity, and harness geometry that transfers lift efficiently.
- Variables That Matter:** Reactant amounts (baking soda or peroxide), bottle/balloon seal quality, balloon size, harness mass, string routing friction, and presence of foam/soap (can trap gas but add mass).

Expected Results Pattern

Ghost Balloon STEM Investigation

Driving Question

How does the reactant amount affect balloon lift performance in a ghost balloon device?

Hypothesis

Write a testable hypothesis predicting which reactant amount will produce the greatest lift and fastest time to target, and why.

Variables

Type	Describe for This Experiment
Independent Variable	Reactant amount (e.g., baking soda in tbsp; vinegar kept constant)
Dependent Variables	Max lift height (cm); time to reach target height (s); success (Y/N)
Controlled Variables	Bottle/balloon type, seal method, vinegar volume, room conditions, measurement method

Experimental Design

- Test five reactant levels: 0.5, 1.0, 1.5, 2.0, and 2.5 tbsp baking soda with a constant 60 mL vinegar (or choose analogous stepped levels for the H₂O₂ route).
- For each level conduct 3 test trials using the same trigger method (drop-in packet or balloon pre-load).
- Measure maximum height, time to reach 10 cm.

Condition: 0.5 tbsp

Trial #	Max Height (cm)	Time to 10 cm (s)
1		
2		
3		

Condition: 1.0 tbsp

Trial #	Max Height (cm)	Time to 10 cm (s)
1		
2		
3		

Condition: 1.5 tbsp

Trial #	Max Height (cm)	Time to 10 cm (s)
1		
2		
3		

Condition: 2.0 tbsp

Trial #	Max Height (cm)	Time to 10 cm (s)
1		
2		
3		

Condition: 2.5 tbsp

Trial #	Max Height (cm)	Time to 10 cm (s)
1		
2		
3		

Summary Table

Reactant Amount	Avg Max Height (cm)	Avg Time to 10 cm (s)
0.5 tbsp		
1.0 tbsp		
1.5 tbsp		
2.0 tbsp		
2.5 tbsp		

Graphing

Create a bar graph with Avg Max Height (cm) on the y-axis vs Reactant Amount on the x-axis.



Analysis Questions

- Which reactant amount had the best overall performance? Include height, time, and success rate in your answer.
- What controlled variables were most important to keep the test fair?

Implementation Notes

- Assign roles: Builder, Measurer, Recorder, Safety Lead. Rotate between trials.
- Mark a consistent test area and a target height on a wall or meter stick.
- Two safe chemistry routes: (A) Baking soda + vinegar; (B) Yeast + 3% H₂O₂ with a small amount of dish soap in the bottle to visualize gas. Choose one route and keep it consistent.

Teacher Notes on Common Pitfalls and Fixes

- Leaky seals reduce inflation: Stretch balloon neck before use and secure with rubber band + tape over the bottle threads.
- Excess liquid mass: Using too much vinegar/peroxide adds weight; optimize amounts rather than 'more is better.'
- Inconsistent triggering: Pre-load baking soda in the balloon and flip to start reaction or use a tissue packet as a delayed-release pouch.

Analysis Questions KEY

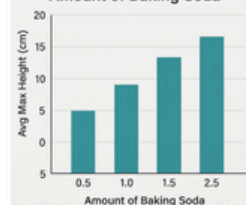
- Best condition: Typically, a mid-level reactant amount (e.g., 1.0–1.5 tbsp baking soda with 60 mL vinegar) that maximizes gas while minimizing mass and leaks. Results vary by class.
- Controlled variables: Bottle/balloon type, cap/neck seal method, puck mass, target height, test surface, room conditions, measurement method (same ruler/observer).

Answer Key and Sample Results

Illustrative data—class results will vary

Reactant Amount (tbsp baking soda)	Avg Max Height (cm)	Avg Time to Target (s)
0.5	6	—
1.0	12	18
1.5	16	12
2.0	15	14
2.5	13	16

Average Maximum Height vs. Amount of Baking Soda



Rubric

Category	Exceeds (4)	Meets (3)	Approaches (2)	Beginning (1)
Experimental Design	Variables clearly named; standardized trigger; success defined; enough trials across 5 levels.	Variables named; mostly consistent; trials completed.	Variables partly named; inconsistent procedure; fewer trials.	Variables missing; no consistent procedure.
Data Quality	All trials recorded; clear units; averages computed; invalid trials noted & redone.	Most trials recorded; summary mostly complete.	Several omissions; summary incomplete.	Many missing; summary not usable.
Graphing & Analysis	Correct graph with labels; bars accurate; clear takeaway naming best level with numbers.	Graph present with titles and labels; takeaway stated.	Graph incomplete or unclear; vague takeaway.	No graph or incorrect.
Claim-Evidence-Reasoning	Claim cites best level; evidence uses this lab's data; reasoning connects gas generation, seal, and lift.	Claim supported with basic evidence; some correct reasoning.	Claim weakly supported; unclear reasoning.	Claim absent or unrelated.
Collaboration & Safety	Roles used; area organized; eye protection; on-task.	Mostly cooperative; safe with minor reminders.	Uneven participation; repeated reminders.	Off-task or unsafe behavior.

What You Get

- **Teacher Guide:** Setup checklist, materials, safety, timing/roles; background on center of mass, rotation, fluid damping; quick troubleshooting + extensions.
- **Student Packet:** Driving question, hypothesis template, variables table (IV/DV/controls), numbered step-by-step procedure.
- **Data Tables (0%, 25%, 33%, 50%, 75%):** Trial logs with spaces for averages, success counts, quick notes.
- **Analysis + Model Answers:** Focused questions on best fill level, errors, improvements; concise answer key.
- **Simple Rubric:** Single-point rubric with 4 performance levels.