The Great Kitchen Chemistry Challenge: Mastering Experimental Design

Materials Needed:

- Clear jars, tall glasses, or small plastic bottles (at least 2)
- Notebook or experiment log sheet (for recording data) and pen
- Measuring cups and spoons
- Water
- Rubbing alcohol (or corn syrup, if alcohol is unavailable)
- Cooking oil (vegetable or canola)
- Honey or corn syrup
- Food coloring (3 different colors)
- Dish soap
- Baking soda (Sodium Bicarbonate)
- Vinegar (Acetic Acid)

Learning Objectives (Learners will be able to):

1. Define and apply the five core steps of the Scientific Method (Observation, Hypothesis, Experiment, Analysis, Conclusion).
2. Formulate a testable hypothesis regarding density and liquid layering.
3. Successfully execute two controlled experiments: a Density Tower and a Chemical Eruption.
4. Analyze the experimental results and communicate conclusions based on evidence.

I. Introduction (15 Minutes)

Hook: The Mystery of the Unmixable Liquids

Educator Prompt: If you dropped a coin into a glass of water, it sinks. If you drop an ice cube in, it floats. If you mix oil and vinegar for salad dressing, they separate. Why do certain substances resist mixing, and why do some float while others sink, even if they look similar?

Reviewing the Scientific Method (I Do)

The foundation of all great science is the Scientific Method. Before we mix anything, we must agree on the rules of the game.

1. **Observation/Question:** What are you trying to figure out? (e.g., Will different liquids stay separate?)
2. **Hypothesis:** An educated, testable guess or prediction. (e.g., I predict the heaviest liquid will sink to the bottom.)
3. **Experiment:** Testing the hypothesis while controlling variables.
4. **Analysis:** Recording and looking closely at the data/results.
5. **Conclusion:** Was the hypothesis correct? What did the experiment prove?

Success Criteria Checkpoint: Learners should be able to state the Scientific Method steps in order.

II. Body: Content & Practice (45 Minutes)

Activity 1: The Density Tower Challenge (I Do, We Do)

Concept Focus: Density (mass per unit volume). Different liquids have different densities, causing them to layer when poured carefully.

A. Setup & Hypothesis (I Do - Modeling)

1. **Educator Modeling:** Introduce the four liquids (honey, water, oil, alcohol). Explain that density is determined by how tightly packed the molecules are.
2. **Question:** Which of these four liquids is the most dense, and which is the least dense?
3. **Hypothesis Formulation (We Do):** Have the learner predict the stacking order from heaviest (bottom) to lightest (top).

   Example Hypothesis Template: "I hypothesize that [Liquid A] will sink to the bottom because it is the most dense, and [Liquid D] will float on top because it is the least dense."

4. **Procedure Review:** Emphasize that liquids must be poured slowly and directly into the center of the jar to prevent mixing.

B. Execution & Analysis (We Do - Guided Practice)

1. Pour the designated liquids one by one into the clear jar, starting with the predicted heaviest liquid. (Recommendation: Honey, Dish Soap, Water (add a drop of blue food coloring), Oil, Alcohol (add a drop of red food coloring)).
2. **Data Collection:** Record observations in the log book immediately after each liquid is added. (Did it mix? Did it settle above or below the previous liquid?)
3. **Formative Assessment:** Ask the learner: "If a layer is floating high up, what does that tell us about its mass compared to the layer below it?" (Answer: It is less dense.)

Activity 2: The Eruption Experiment (You Do)

Concept Focus: Chemical Reactions (Acid-Base). Mixing baking soda (a base) with vinegar (an acid) produces carbon dioxide gas, causing foam and eruption.

C. Design & Experimentation (You Do - Independent Application)

1. **New Hypothesis:** Have the learner formulate a hypothesis about variables.

   Example Question: "Will adding dish soap to the mixture make the eruption bigger or last longer?"

   Example Hypothesis: "I predict that adding 1 tablespoon of dish soap will create a taller eruption because the soap will trap the CO_2 gas."

2. **Setup:** Use the second clean jar. The learner decides the amounts (within safe limits, e.g., 2 Tbs baking soda, 1/2 cup vinegar) and adds the dish soap, if included in the hypothesis. (Encourage them to add food coloring to the baking soda mix first for dramatic effect.)
3. **Action:** Pour the vinegar rapidly into the jar containing the baking soda/soap mixture.
4. **Analysis:** Record the observations (height of eruption, duration, color).

III. Conclusion (15 Minutes)

A. Conclusion & Recap (Tell Them What You Taught)

Reflection Discussion:

- Review the Density Tower: Were the hypotheses about density correct? Which liquid surprised you the most?
- Review the Eruption: What was the chemical byproduct that caused the eruption? (CO_2 gas) Was the hypothesis about the dish soap correct?
- Emphasize that both activities required all five steps of the Scientific Method.

B. Summative Assessment: The Experiment Report

The learner must complete a brief written or verbal report covering one of the two experiments (learner's choice) using the following success criteria:

1. Clearly state the initial question.
2. State the exact hypothesis they tested.
3. Describe the procedure briefly (what they mixed/poured).
4. Present the results (what happened?).
5. Draw a conclusion: Was the hypothesis supported or refuted, and why?

C. Differentiation and Extension

Scaffolding (For learners needing extra support):

- Provide pre-measured quantities for the Eruption Experiment to eliminate measurement error risk.
- Use a provided checklist for the Density Tower pouring sequence instead of relying solely on the hypothesis.

Extension (For advanced or quick learners):

- **The Lava Lamp Challenge:** Challenge the learner to use the density knowledge and chemical reaction knowledge to create a functioning, long-lasting density tower that reacts dynamically (requires adding Alka-Seltzer tablets, which react with water to produce CO_2).
- **Quantitative Analysis:** Research the actual densities (g/mL) of the four liquids used in the Density Tower and compare the real values to the visual results.