This material is based on work supported by the National Science Foundation under Grant No. DUE 9987332.

Activities

Teaching Questions:

1. What are Ms. Saccharin's complaints? (Brainstorm)

2. Can you reword the complaints in the form of questions that you can investigate?

3. Based on your question, write a hypothesis that would provide a causal explanation in answer to your question.

4. Design a controlled experiment to test your hypothesis.

5. Write a report describing your experiment and results.

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Teachers:

Conducting a Controlled Experiment

Hand out the background story and include a baggie for each group of students with a representative "sample" of candies of the kind that Ms. Saccharin had complained about.

Materials

Option 1: If you are only investigating the complaint about how fast some candies dissolve, each baggie will only need to include 1 of each shape in the sample. You might also include instructions on measuring surface area and volume. You will need to provide balances, rulers/and or tape measures. Each student or group of students should receive hard candies in the following shapes (as available)—spheres (balls), discs, rods, squares, and barrels. If possible, the candies should be all the same flavor (However, flavor can be a variable which they choose to test). The candies should be individually wrapped, hard candies. Most of these should be readily available at major supermarket chains or discount stores. Diabetic students can be accommodated by providing sugar-free substitutes. If you wish, you can add the variable "sugar-free" to the list.

Option 2: Instead of actual candies, you provide students with pictures of candies Pictures of several different types of candies are provided. You could also provide students with counts of the different types of candies in a "random" sample of bags.
The activities for this option are Parts A, B, and C only (see below).

Option 3: If you are including the complaint about over representation of the fastest dissolving candies, you have two options: A) before placing the candies in bags, mix them thoroughly, then draw random samples of at least 30 pieces of candy in each sample. This option should indicate that there is no over representation of any one type of candy. B) "Doctor" your samples so that the candy that dissolves the fastest (the one with the greatest SA/V ratio) is included more often (2-3X more) than the other candies.

Part A. Defining the problem.

Teaching Questions:
1. What are Ms. Saccharin's complaints? (Brainstorm)

> Formative Assessment:
> What observation(s) is/are Ms. Saccharin using to base her complaint on?

2. Can you reword the complaints in the form of questions that you can investigate? (Brainstorm—List questions on the board) [Sample questions: Do all the candies in the sample dissolve at the same rate? Are there the same numbers of each type of candy in the bag?] Try to

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encourage more ideas–then come back and ask the students to eliminate ones that could not be easily tested or are not relevant. Steer the discussion to pare down the list to one or two major questions. "Do all the candies dissolve at the same rate?" or "What factors affect the rate at which candies dissolve?" You may end the discussion by saying, "Those are some interesting questions but let's investigate this one" and provide the question of your choice.

Part B. Possible explanations.

Teaching Questions:
1. Based on your question, write a hypothesis that would provide a causal explanation in answer to your question.

Mini-teach: Testable Hypothesis. A good hypotheses has the following characteristics:

1. Based on observations–why would Ms. Saccharin think that the candies didn't all dissolve at the same rate?
2. Provides a causal explanation–should answer the question why or how. "The candies don't dissolve at the same rate ***because*** they are different shapes." Because answers the question "Why".
3. Testable AND falsifiable–doesn't rely on supernatural or unobservable explanations.
4. Generates predictions–A prediction is what you think the outcome of the experiment should be. You should be able to explain what your data will look like if the hypothesis is supported–and if it is not. " If the candies don't dissolve at the same rate because they are different shapes, then those with a greater volume should dissolve more slowly." Predictions should be directional–more or less slowly or faster or....
5. They are supported or not supported. One of the most overused (and incorrectly used) terms in science is the word "proven". We often see scientists in the media claim to have "proven" their theory or hypothesis. Proof means it is a 100% absolute certainty that their explanation for the observed phenomenon is correct. There are very few absolutes–unless you are 100% certain that you have accounted for all the variables, you cannot say you have proven–or disproven–your hypothesis.