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Science Skills **Introduction Investigation A**

Evaluating Precision

Introduction

When an object is measured more than once, the measurements may vary. The closeness of a set of measured values to each other is called **precision.** Many people confuse precision with accuracy. **Accuracy** is a measure of how close the values are to the actual value. A set of values can be in close agreement, or precise, without being accurate.

For example, suppose you repeatedly measure the mass of a 4.00-g mineral sample by using a balance that reads too low by 3.00 g every time. You might get nearly identical readings—for example, 1.00 g, 1.01 g, and 0.99 g. These readings are quite precise because they are close together. However, they differ from the actual value by a large amount. Therefore, the measurements are very inaccurate.

In this investigation, you will make several measurements of length, temperature, and volume. Then, you will evaluate the precision of your measurements by comparing them to measurements made by your classmates.

Problem

How can you determine the precision and accuracy of measurements?

Pre-Lab Discussion

Read the entire investigation. Then work with a partner to answer the following questions.

1. **Applying Concepts** Use the example of a series of repeated length measurements to explain the meaning of precision.

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2. **Inferring** What information would you need to determine the accuracy of a measurement?

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3. **Drawing Conclusions** In this investigation, you will compare measurements that you make to measurements that your classmates make. Will you do this to determine the accuracy or the precision of your measurements?

4. **Designing Experiments** Identify the manipulated, responding, and controlled variables in this investigation.

   a. Manipulated variable

   b. Responding variable

   c. Controlled variables

5. **Analyzing Data** Two students measure the mass of a wooden disk, using the same balance. The first student repeats the weighing three times and obtains mass readings of 47 g, 52 g, and 51 g. The second student obtains mass readings of 45 g, 55 g, and 50 g. Explain which set of measurements is more precise. Can you tell if the measurements are accurate? Why or why not?

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Materials *(per group)*

meter stick

Celsius thermometer

500-mL beaker filled with room-temperature water

10 pennies

50-mL graduated cylinder

Safety

Put on safety goggles and a lab apron. Be careful to avoid breakage when working with glassware. Note all safety alert symbols next to the steps in the Procedure and review the meaning of each symbol by referring to the Safety Symbols on page xiii.

Procedure

1. You and your partner make up a team. Your team and two other teams will make up a group of six. Your teacher will tell you and your partner whether you are Team A, B, or C of your group. The three teams in your group will measure the same objects separately. You will not share your measurements with the other teams in your group until you complete the procedure.
2. Working with your partner, use the meter stick to measure the length of a desk indicated by your teacher. Measure as carefully as possible, to the nearest millimeter. Record the length of the desk in the Data Table. (*Hint:* Do not reveal the measurements you make to the other teams in your group. They must make the same measurements and must not be influenced by your results.)
3. Use the thermometer to measure the temperature of the beaker of room-temperature water. **CAUTION:** *Do not let the thermometer touch the beaker.* Record this measurement in the Data Table.
4. Place 25 mL of tap water in the graduated cylinder. Measure the volume of the water. Record this volume in the Data Table to the nearest 0.1 mL. (*Hint:* Remember to read the volume at the bottom of the meniscus.)
5. Add the 10 pennies to the graduated cylinder. Read the volume of the water and pennies. Record the volume the nearest 0.1 mL in the Data Table.
6. Subtract the volume of the water from the volume of the water and pennies. The result is a measurement of the volume of the pennies. Record this value in the Data Table.
7. After all three teams in your group have finished measuring the same objects for length, temperature, and volume, share your results with the other two teams. Record their measurements in the Data Table.

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Observations

DATA TABLE

Measurement	Team A	Team B	Team C
Length of desk (mm)			
Temperature of water (°C)			
Volume of water (mL)			
Volume of water and pennies (mL)			
Volume of pennies (mL)			

Analysis and Conclusions

1. Calculating Average the three length measurements you compared by adding them together and dividing the result by 3. Find the range of values by calculating the difference between the largest and smallest values. Record the results of your calculations in the space below.

a. Average of length measurements (mm)

_____

b. Range of length measurements (mm)

_____

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2. **Making Generalizations** Would it be correct to use the range of values you calculated in Question 1 to describe the precision of the measurements? The accuracy of the measurements? Explain your answer.

3. **Analyzing Data** Which of the three sets of measurements had the least spread among the measurements? Suggest reasons for the precision of these measurements.

4. **Applying Concepts** Figure 1 shows the results of three people's attempts to shoot as many bull's-eyes as possible. Below Figure 1, label each of the results as *accurate* or *not accurate,* and as *precise* or *not precise.*

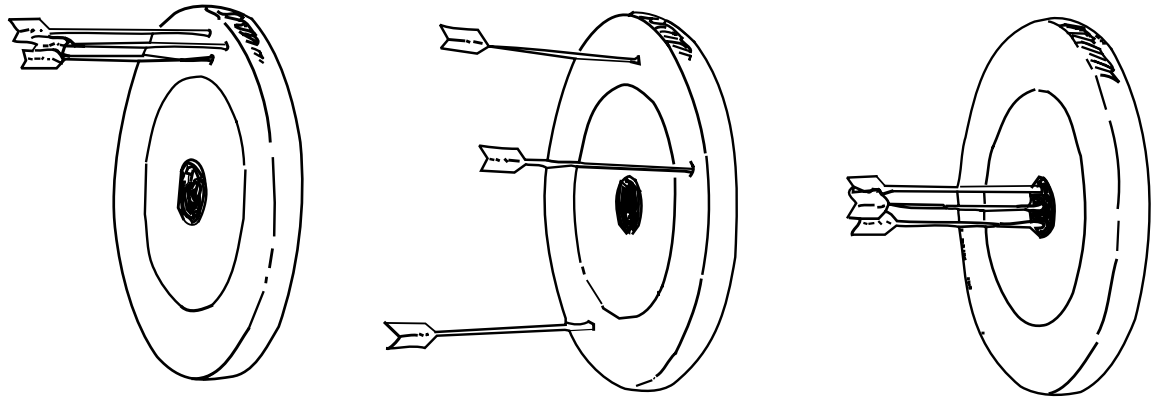

Figure 1

5. **Evaluating and Revising** Discuss the reasons for the differences among the teams' measurements with the members of your group. Describe these reasons and explain how the measurements could be made more precise.

Go Further

Design an experiment to compare the precision of two or more measuring instruments. Is the precision of each instrument the same throughout its range of measurements? Write a procedure you would follow to answer these questions. After your teacher approves your procedure, carry out the experiment and report your results.