Healthy Water, Healthy People

by John Etgen

"Thump! Thump! Thump!" The sound of small balls of clay hitting paper targets echoes through the classroom as students design ways to consistently drop clay balls onto a bull's-eye. These students are participating in a hands-on activity called Hitting the Mark (see pages 28–30), which uses common items (balls of clay and paper targets) to illustrate the concepts of accuracy and precision. Through this activity, students not only learn the fundamental principles of accuracy and precision, but also the importance of writing clear procedures, eventually connecting both concepts to a broader view of water quality measurement.

Hitting the Mark is one of 25 innovative hands-on activities found in the new *Healthy Water, Healthy People Water Quality Educators Guide*. The guide is one component of a much larger water quality education program called Healthy Water, Healthy People, based at the Project WET headquarters at Montana State University in Bozeman, Montana. Additional materials include a series of testing kits and a technical reference publication, the *Healthy Water, Healthy People Testing Kit Instructors Manual*. Together these materials cover a variety of grade levels and water quality testing situations, from upper elementary through high school. These materials are distributed free of charge to participants in Make a Splash with Project WET water festivals (see Sidebar for more details) or they can be purchased directly from the Healthy Water, Healthy People website at *www.healthywater.org*.

Project WET, (Water Education for Teachers) a national and international water science and

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Project WET water festivals

The third annual National Project WET Water Education Day is scheduled for September 27, 2002. On this date, over 50,000 students, teachers, parents, and citizens will participate in Make a Splash with Project WET water festivals in all 50 states and the District of Columbia to celebrate and learn about water, our most precious natural resource. The events are sponsored by Nestle Waters of North America in partnership with Project WET USA.

Healthy Water, Healthy People will be highlighted at this yearís festivals, and each student who attends a festival will receive the 16-page Healthy Water, Healthy People KIDs (Kids In Discovery Series) student activity booklet. In addition, festivals will have a Healthy Water, Healthy People Water Quality Education station, sponsored by the Hach Company, featuring a hands-on activity and testing equipment illustrating concepts of water quality.

To learn more about this exciting event and learn how you can participate in next yearís festivals, contact the Project WET USA office at (866) 337-5486, email *projectwet@montana.edu,* or visit their website at *www.projectwet.org.*

education program for educators in grades K–12, has partnered with the Hach Scientific Foundation to develop the Healthy Water, Healthy People program. Their shared goal is to make the complex concepts associated with water quality understandable and relevant for students and teachers alike. With so many educators monitoring water quality, there is a need for clear understanding of the relationship between water quality and human and environmental health, the connection between water quality and land uses, and the process of analyzing and interpreting data. Healthy Water, Healthy People activities and materials give educators the tools to address these needs in hands-on, interactive ways.

The activities were developed by teachers working with water quality experts and follow the latest science education reform principles. They are correlated to the *National Science Education Standards* and promote inquiry-based investigations and critical thinking, cooperative learning, and problem-solving skills. Concept mapping, KWL investigation processes, and web quests are highlighted, along with ideas for how the materials can be used in science fair projects and student-directed learning.

Water and water quality are unifying topics for integrating science with other disciplines. As evidenced in Hitting the Mark, general science inquiry concepts are integrated with chemistry, language arts, and mathematics. There are further connections to health, social studies, and life science. There is a strong connection to technology, including student evaluation criteria for website resources, connections between the printed materials and a dynamic website to encourage deeper investigation of the topics, and the hands-on technology of the Healthy Water, Healthy People testing kit series.

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Learn more about water quality at *www.scilinks.org.* Enter code SS90202.

Training workshops for implementing the Healthy Water, Healthy People program will be available at upcoming NSTA conferences, and can also be made available locally by contacting the program director. Keep apprised of Healthy Water, Healthy People workshop opportunities by joining the Healthy Water, Healthy People Newsgroup through the website at *www.healthywater.org.* For more information, call toll free at (866) 337-5486, or email *healthywater@montana.edu*.

Helping students understand the relationship of healthy water to healthy people and environments is a critical link as they face future water quality challenges and opportunities. Join other teachers who are rising to this challenge while meeting state and district standards through the innovative, hands-on, and standards-based materials of the Healthy Water, Healthy People program.

Standards

The Hitting the Mark activity meets the following *National Science Education Standards* for Grades 5ñ8:

Standard: Unifying Concepts and Processes
As a result of activities in grades Kñ12, all students should develop understanding and abilities aligned with the following concepts and processes:

ï Evidence, models, and explanation
ï Constancy, change, and measurement
ï Form and function

Content Standard A: Science as Inquiry
As a result of activities in grades 5ñ8, all students should develop:

ï Abilities necessary to do scientific inquiry
ï Understandings about scientific inquiry

Content Standard G: History and Nature of Science
As a result of activities in grades 5ñ8, all students should develop understanding of:

ï Science as a human endeavor
ï Nature of science

Hitting the Mark

Summary

Students investigate the concepts of accuracy and precision in data collection, and learn the importance of writing detailed procedures.

Objectives

Students will:

- distinguish between accuracy and precision.
- investigate the relationship of accuracy and precision as it relates to water quality data collection.
- write clear procedures and recognize the limitations of those procedures.

Materials

- Copies of Accuracy and Precision Illustrations (page 30, top)
- Clay (enough for each group to have at least a 3" x 1" x 1" piece)
- Copies of target (page 30, bottom)
- Meter stick or tape measure
- Pencils and paper
- Colored pencils, markers, or crayons (at least 3 different colors for each group)

Background

To investigate higher-level concepts of water quality, fundamental principles must first be understood. Data accuracy and precision is one fundamental principle that leads to a broader understanding of higher-level water quality concepts.

Data is a part of our lives in more ways than we may realize. We are bombarded daily with data from media and computers. We use data to determine if our vehicles are low on gas, how much chlorine is added to our drinking water during treatment, and even our watches give us data about the time of day.

The accuracy and precision of data is critical. We come to rely on data from a watch that is working correctly and is set to the actual time. However, if a watch is set one hour faster than the actual time we know that it is not accurate, but it is still precise because it moves at a consistent rate around the dial. Of course, the most valuable watch is one that gives the correct time all the time, yielding data that is both accurate and precise.

Likewise, accuracy and precision are critical for water quality data. Because data collection is such an important component of water quality monitoring, the United States Environmental Protection Agency (EPA) has established Data Quality Objectives (DQOs). These objectives, which include accuracy, precision, representativeness, completeness, and comparability, are used to determine whether data is meaningful and valid (Mayio 1996). This activity focuses on accuracy and precision.

Accuracy is a measure of how close results are to the actual value. Using a dartboard and bull's-eye analogy, accurate darts would all be fairly close to—but not necessarily in a tight cluster in—the center of the bull's-eye. In water quality testing, accurate results could mean that three pH tests all measured very closely to the actual pH of the water.

Precision is how consistent measurements are with each other rather than with the actual value. For example,

HEALTHY WATER HEALTHY PEOPLE

Grade Level:
6–9

Subject Areas:
General science, Environmental science, Chemistry, Mathematics, Biology

Duration:
Preparation: 30 minutes
Warm Up and Part I: 50 minutes
Part II: 30 minutes

Setting:
Classroom

Skills:
Experiment design, Procedure design, Analyze, Interpret, Collect Data, Apply, Present

Vocabulary:
accuracy, precision, standards

if you were trying to hit the bull's-eye of a dartboard, precision is demonstrated when the darts are clustered together, but not near the bull's-eye. In water quality testing, an example of precision is when three pH tests yield the same result, but that result is not close to the actual pH of the water.

The reliability of water quality data depends on its accuracy and precision, as well as the concepts of data representativeness, completeness, and comparability. Understanding fundamental water quality principles such as accuracy and precision can be a springboard to investigating higher-level water quality concepts.

Procedure

Warm up

Discuss the definitions of accuracy and precision. Have students brainstorm ways that accuracy and precision are important in their lives. Distribute copies of *Accuracy and Precision Illustrations* (page 30, top), or make a transparency and place it on an overhead projector. Have students determine which of the illustrations is 1) neither accurate nor precise; 2) accurate but not precise; 3) precise but not accurate; and 4) both accurate and precise. Explain that they will now create their own demonstrations of accuracy and precision.

The activity

Part I

1. Divide students into small groups and distribute one piece of clay and a target (page 30, bottom) to each group.
2. Instruct each group to create five balls of equal size and shape from the clay. (Different groups may have different sized clay balls.)
3. Explain that their task is to drop the clay balls as close to the center of the target as possible from a height of no less than one meter (3.3 ft.). The target should be placed on a flat, hard (non-carpeted) surface such as a floor, table, or desk.
4. Have the students experiment with different ways of dropping the balls onto the target to maximize their precision and accuracy.
5. When the individual groups devise a method that they feel is accurate and precise, instruct them to record detailed procedures for this method. Using their written procedures, have the students conduct three separate trials and record their results directly on the target using three different colored pens to signify each trial.
6. Have each group present their procedures and results. Were their results both accurate and precise? Discuss with the students what could explain any variability of the results between the groups.

Part II

7. Have groups switch places with another group so they are using another group's procedures, targets, and clay balls.
8. At their new location, instruct each group to carefully read the new procedures and conduct three trials using the new procedures and materials, and record their results.
9. Have each group present their new procedures and results. Were there any differences in the accuracy and precision of the results between Part I and Part II? Ask if there were any difficulties following another group's procedures. What were the primary causes of these difficulties? Ask the students how difficulty in following someone else's procedures could lead to inaccuracy in water quality data collection.

Wrap up

Have students write a paragraph describing the difference between accuracy and precision. Ask students how difficult it was to be accurate and precise using their own procedures. Using another group's procedures? Why was there a difference? How important are clear and understandable procedures to collecting useful water quality data? Why?

Assessment

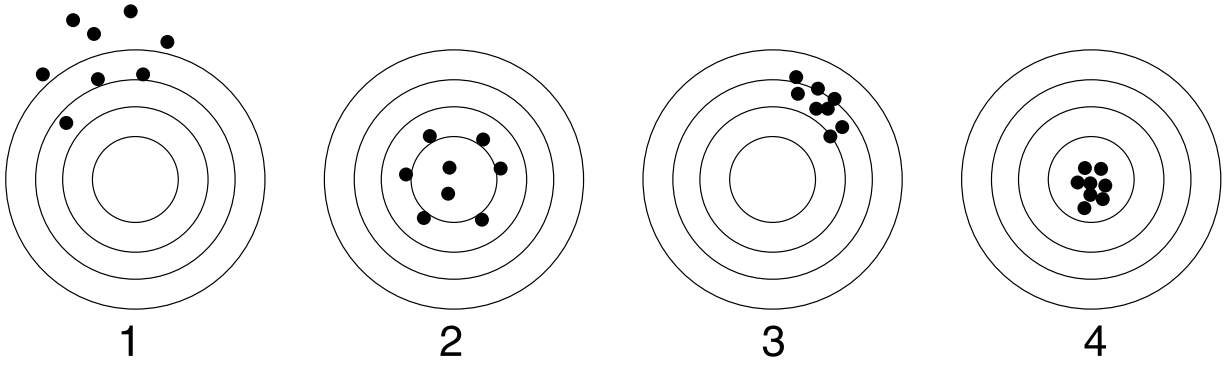
Have students:

- discuss concepts of accuracy and precision (Warm up).
- design their own experiment to demonstrate accuracy and precision (Part I).
- write detailed procedures outlining the steps of an experiment (Part I).
- collect and record data for comparison with other students' results (Part I, II).
- discuss the limitations of procedure writing (Wrap up).

Resources

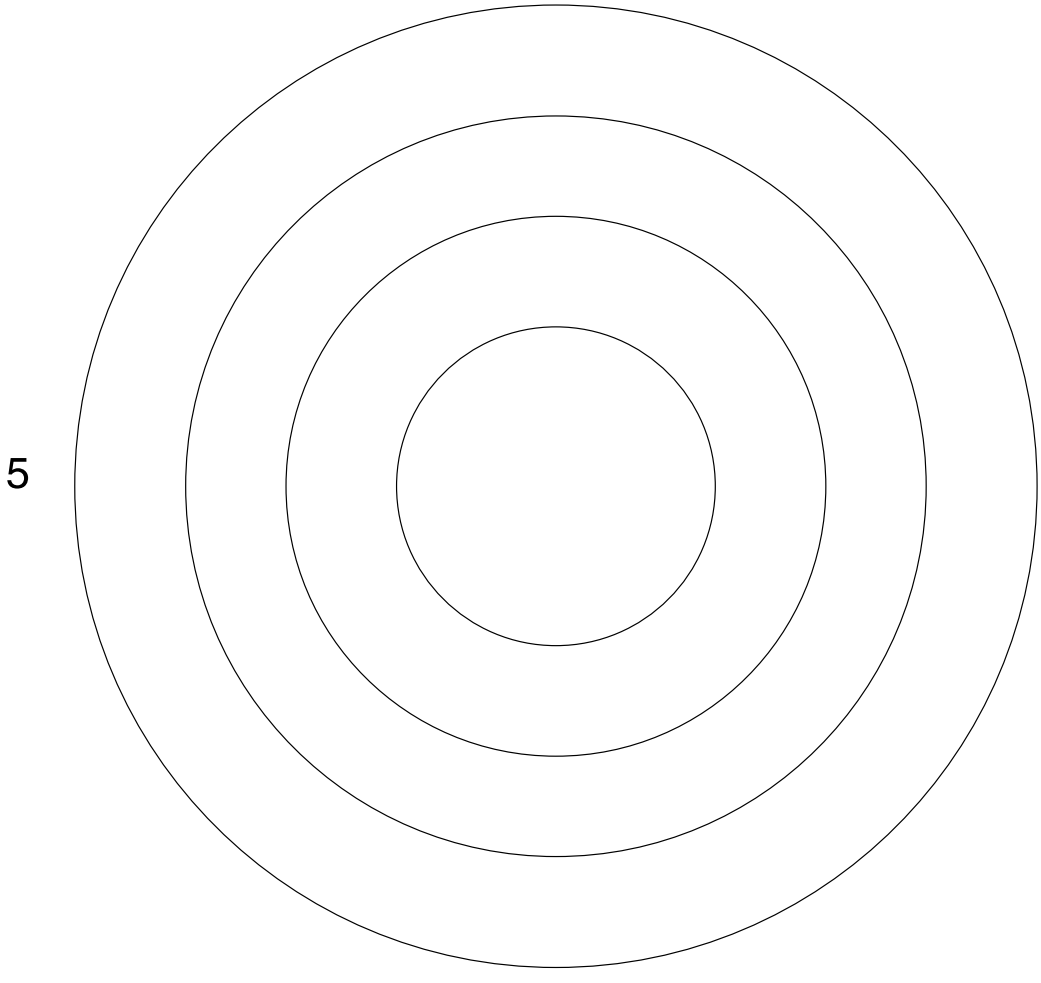
Dates, G. 1995. *River Monitoring Study Design Workbook*. Montpelier, Vermont: River Watch Network.
Hach Company. 1997. *Water Analysis Handbook*. Loveland, Colorado: Hach Company.
Mayio, A. 1997. *Volunteer Stream Monitoring: A Methods Manual*. Washington, D.C.: United States Environmental Protection Agency.

Accuracy and precision illustrations



1 2 3 4

Target



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Adapted with permission from *Water Analysis Handbook*. Hach Company: Loveland, Colorado.