Lesson Title	Making Many Measurements Meaningful
Length of Lesson	One (50 minute) class period
Created By	Bo Cherry
Subject	General Science
Grade Level	7th grade
State Standards	7th: 1 c,f (Inquiry); 2 b (Physical Science)
DOK Level	DOK 2
DOK Application	Separate, Compare, Relate, Make Observations
National Standards	5-8: A (Inquiry); B (Physical Science)
Graduate Research Element	Making measurements such as length, volume, and pH are fundamental parts of research in hydrology.

Student Learning Goal:
MS 7th Grade:
(Inquiry) 1 (c) Collect and display data using simple tools and resources to compare information; (f) Explain how science and technology are reciprocal; (Physical Science) 2 (b) Categorize types of chemical changes, including synthesis and decomposition reactions, and classify acids and bases using the pH scale and indicators.

National Science Education Standards of Content 5-8:
(Inquiry - A) Abilities necessary to do scientific inquiry; Use appropriate tools and techniques to gather, analyze, and interpret data; Use mathematics in all aspects of scientific inquiry; (Physical Science - B) Properties and changes of properties in matter.

Materials Needed (supplies, hand-outs, resources)
Litmus paper, hydrion paper, In-Situ pH probe, triple beam balance, digital balance, 500-mL beaker, 200-mL beaker, various sizes of graduated cylinders (3 total), small cube, ruler, tape measure, Disto laser measure, food coloring (for water), dilute acid (i.e. HCl), dilute base (i.e. NaOH), baking soda, vinegar, pan (for baking soda/vinegar reaction).

Lesson Performance Task/Assessment:
In this lesson, students will gain valuable experience using various scientific instruments. For the first part of this lesson, students will choose an object in the classroom that can be measured on both a triple beam balance and a digital balance. The instructor will have the students record the measurements as they go. Short discussions will follow each measurement to show how different techniques can lead to different results and accuracies.

Next, students will measure from one end of a hall to another. Students will be asked first to write on paper their estimate as to how far they think the distance will be. Next, two students will volunteer to measure the hallway with the tape measure. This distance will be recorded, then the instructor will demonstrate how to use the Disto laser to measure the same distance. Students may also volunteer to use the Disto laser in order to gain experience using the instrument.

Next, the instructor will use the beakers and graduated cylinders to show how to measure volumes of water (water will contain red food coloring for aesthetics). The same amount of water will be used in each measurement and discrepancies will be discussed. There will be another exercise using the red water in which students will measure the volume of a small cube using a ruler. They will then use the formula (LxWxH) to find the volume of the cube. The instructor will then explain how to find the volume using the graduated cylinder and water displacement.

The final demonstration for this lesson will be using litmus paper, hydrion paper, and a pH probe to compare an acidic and basic sample. The samples will be prepared prior to class and will be very weak acids and bases. A brief discussion on the pH scale and hydrologic research will follow the demonstration.

Lesson Relevance to Performance Task and Students:
This lesson introduces students to various methods used in the scientific world. This lesson shows students how different results may be found using different techniques of measurement. This will be made relevant to the students by discussing how small changes in ocean acidity can drastically change the coral reefs found in warm seas. A short discussion on ocean acidification will tie in the pH readings. It will also be explained how pH is used in hydrologic research. Also, unit conversions may be explained using the tape measure and Disto laser. These conversions will also be made relevant by explaining why the Mars rover failed due to unit discrepancies. Finally, measuring mass will be made relevant by relating this to cooking in the kitchen, or even in pharmaceuticals.

Anticipatory Set/Capture Interest:
In order to capture the students' interest, the instructor will perform the classic baking soda in vinegar experiment, but purposely add too much baking soda. Food coloring will also be added for this demonstration for aesthetics. This will be a perfect transition into the lesson.

Guided Practice:
Much of this lesson will be instructor-led demonstrations. Many discussions will be led by the instructor using leading questions to get students thinking about the discrepancies in the results and why it is important to understand where they come from.

Independent Practice:
Many of the activities will use student volunteers to make measurements. Also, each student will be expected to document all of the measurements on a sheet of paper. Each student will also be able to use the Disto laser measure, and groups may use triple beam balances to measure their masses.

Remediation and/or Enrichment:
Remediation- Individual IEP;
Enrichment - Explain and teach significant figures and how the various instruments provide different significant figures.

Check(s) for Understanding:
The instructor should lead discussion and use formative feedback from those discussions in order to check for understanding. Also, the instructor should constantly check students' papers to ensure that they are keeping up with the data. Later, hands-on lessons in chemistry will allow students to use the equipment, so this will be another way to check for understanding.

Closure:
Question 1: What are some sources of error when measuring mass? Volume? Distance?

Question 2: Which method is better for measuring the volume of the small cube?
Justify your answer.

Possible Alternate Subject Integrations:
Chemistry, Physical Science, Mathematics

Teacher Notes:
During the anticipatory set, make sure to run the baking soda/vinegar reaction inside a pan to make the clean-up process easier.

If a pH probe is not available, just use the two different types of paper.

In order to protect the digital balance, have one volunteer from each group use the balance with the instructor, then report the data to their group.