SPLAT!
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Annotation
In this laboratory exercise, students will measure the relative viscosities of several common food liquids and construct a standard curve to estimate the viscosity of glycerin.

Primary Learning Outcome:
Students will be able to define the term *viscosity* and identify viscosity as a physical property of matter.

Students will be able to construct and interpret a standard curve using reference and experimental data.

Students will be able to describe, in written and/or graphic form, an inverse relationship between two variables.

Students will be able to explain whether experimental data supports a stated hypothesis.

Students will be able to describe sources of error and potential improvements in an experimental design.

Georgia Performance Standards:
Characteristics of Science
SCSh2. Students will use standard safety practices for all classroom laboratory and field investigations.

SCSh3. Students will identify and investigate problems scientifically.

SCSh4. Students will use tools and instruments for observing, measuring, and manipulating scientific equipment and materials.

SCSh5. Students will demonstrate the computation and estimation skills necessary for analyzing data and developing reasonable scientific explanations.

SCSh8. Students will understand important features of the process of scientific inquiry.

Physical Science Content
SPS2. Students will explore the nature of matter, its classifications, and its system for naming types of matter.

Chemistry Content
SC1. Students will analyze the nature of matter and its classifications.

Duration:
Preparation: 30 minutes
Introduction: 10 minutes
Student Assignment: 30 minutes
Conclusion: 20 minutes
Total Class Time: 60 minutes

Materials and Equipment:
For Teacher Preparation:
1. 10-mL Plastic disposable syringes
2. Utility knife
3. Semi-log graph paper
4. Ring stands and clamps
5. Metric ruler
6. Test liquids – olive oil, corn syrup, molasses, honey, chocolate syrup, sour cream, peanut butter

Per Group:
1. 1 Viscosity dropper setup
2. Several paper targets
3. 20-mL Samples of each test liquid

Safety:
There are no significant safety concerns associated with this activity.

Technology Connection:
Not applicable.

Procedures:
Teacher Preparation:
For each student prepare a copy of the *Splat!* student handout. Prepare viscosity droppers by cutting the tip off of each of the syringes at the 10-mL mark with a utility knife. For each setup, attach a clamp to the ring stand at the maximum height possible. Ensure that all setups are congruent in height.

Introduction:
Think about pouring yourself a nice big glass of milk. Next, think about pouring some sweet maple syrup on a stack of pancakes. Now think about pouring some tasty peanut butter onto a slice of bread for a sandwich! What do you mean you can't pour peanut butter out of a jar? Peanut butter is a fluid just like milk or syrup, right? So what's the difference? Why is milk much more "pourable" than peanut butter? You might say that the peanut butter is "thicker" than the milk. That's close, but the real answer is viscosity.

Viscosity is a quantity that describes a fluid's resistance to flow. This resistance is caused by the intermolecular attraction of the molecules making up the fluid. You can think of viscosity as the "thickness" of a fluid (a liquid in this case). So the higher a liquid's viscosity, the harder it is to pour. Viscosity is an important property of many fluids that we encounter daily. Viscosity influences the texture and desirability of the foods we eat, the effectiveness of cooking oils, and the processing and packaging of our foods.

Explain to students that there are lots of ways to measure viscosity, ranging from very simple to very complex, and in this laboratory exercise, they will evaluate a fun, messy way of testing viscosity – the "viscosity splat test." You may use the following script as a guideline to introduce the laboratory exercise to students.
"I hypothesize that the diameter of the splat made by a liquid dropped from a set height will be inversely proportional to that liquid's viscosity. What is an inversely proportional relationship? (An inversely proportional relationship is a relationship in which one variable decreases as the other variable increases.) Do you agree with this hypothesis? In other words, I think that a liquid with a low viscosity will produce a large splat diameter and a liquid with a high viscosity will produce a small splat diameter. So how should I test my hypothesis? I have set up several viscosity splat testers around the laboratory. In order to test my hypothesis, we will drop 5 mL of seven different liquids from a set height. After dropping each liquid, we will measure the diameter of the splat left on our paper target. After getting a splat diameter for each liquid, we will plot the splat diameters against known viscosity values for each liquid. (How will we know if my hypothesis is correct?) Let's get started!"

Viscosity values on the student handout are provided in units of centipoises (cP). This is a common unit for measuring viscosity. The SI unit for viscosity is the pascal (Pa), however you may find that your students have an easier time working in centipoises (1 cP = 0.001 Pa). The viscosity of water is approximately 1 Pa.

<u>Laboratory Exercise:</u>
Students should follow procedures outlined in the attached *Splat!* student handout to conduct the viscosity splat test, construct a standard curve, and use the curve to estimate the viscosity of glycerin.

<u>Conclusion:</u>
Following completion of the laboratory exercise, review the procedures for graphing the test data and determining the viscosity of glycerin *(Note: the viscosity of glycerin is approximately 1500 cP)*. You may want to construct a sample graph and review the concept of an inversely proportional relationship. Also, discuss the use of standard curves to validate test results. Once all groups have determined a viscosity for glycerin, compile the class data and have students calculate the class' mean and range values. Discuss with students sources of error and variability of results. You may also want to discuss alternative methods for measuring viscosity. Viscosity may be measured in a number of ways. The viscosity of clear liquids can be measured by timing the descent of a ball or bearing placed in a cylinder of the liquid. Viscosity can also be

determined by measuring the flow of a liquid through a small tube or orifice. Other classrooms experiments measure the rate of flow of a liquid down an inclined plane. Many industrial viscometers measure the resistance of a rotor as it rotates within the liquid.

Another interesting note on viscosity involves ketchup. A fluid can be classified as either Newtonian or non-Newtonian based on its behavior when a force is applied to the fluid. The viscosity of water, a Newtonian fluid, is independent of the force applied. In contrast, the viscosity of ketchup, and other non-Newtonian fluids, is dependent upon the force applied to the fluid. In the case of dilatent fluids, such as the cornstarch and water suspension known as oobleck, the viscosity increases with increased force. That is, the viscosity of a bowl of oobleck would increase as you increased the speed and force of stirring, making it harder to stir the fluid. In the case of ketchup, and other thixotropic fluids, viscosity decreases with increased force. Thus, ketchup flows more easily when more force is applied to it. This means that tapping the side or bottom of your glass ketchup bottle really will get things flowing quickly on to your burger!

Assessment:
Assessment should be based on completion of the *Splat!* student handout.

SPLAT! *Student Handout*

Introduction:
Think about pouring yourself a nice big glass of milk. Next, think about pouring some sweet maple syrup on a stack of pancakes. Now think about pouring some tasty peanut butter onto a slice of bread for a sandwich! What do you mean you can't pour peanut butter out of a jar? Peanut butter is a fluid just like milk or syrup, right? So what's the difference? Why is milk much more "pourable" than peanut butter? You might say that the peanut butter is "thicker" than the milk. That's close, but the real answer is viscosity.

The formal definition of viscosity is the quantity that describes a fluid's resistance to flow. You can think of viscosity as the "thickness" of a fluid (a liquid in this case). So the higher a liquid's viscosity, the harder it is to pour. There are lots of ways to measure viscosity, ranging from very simple to very complex, and in this laboratory exercise, you will evaluate a fun, messy way of testing viscosity – the "viscosity splat test."

Purpose:
To construct a standard curve based on the viscosity splat test and to use the curve to estimate the viscosity of glycerin.

Materials:
1. 1 Viscosity dropper setup
2. Several paper targets
3. Metric ruler
4. 20-mL Samples of each test liquid and glycerin

Procedure:
For each test liquid:
1. Place one paper target beneath the viscosity dropper.
2. Load 5 mL of test liquid into the viscosity dropper.
3. Use the syringe plunger of the viscosity dropper to eject the test liquid, allowing it to drop onto the paper target.
4. After each drop, use the metric ruler to measure the splat diameter for the liquid. This is the diameter of the splat that the liquid makes on our paper target. Measure the main body of the splat. Do not measure all of the small drops that might separate from the main splat. If the splat is not circular, estimate the diameter as if the splat was circular.
5. Record the measured splat diameter on the table below.
6. Repeat these steps for each test liquid and for glycerin.

Viscosity Splat Test Data Table

Date:________ Temperature:________

Substance	Viscosity (cP)	Splat Diameter (cm)
Olive Oil	84	
Corn Syrup	2,500	
Molasses	6,600	
Honey	10,000	
Chocolate Syrup	18,000	
Sour Cream	100,000	
Peanut Butter	200,000	
Glycerin		

Results and Analysis:
Graph your results. Use the data from the table to construct a graph of viscosity versus splat diameter. Use the graph paper provided. For each liquid, plot the point on the graph that corresponds to the intersection of the liquid's viscosity and its splat diameter. Use a straight-edge to draw a best-fit line through your data points.

Discussion & Conclusions:
1. Describe what is meant if we state that "y is inversely proportional to x." You may answer with a sentence or with a simple, labeled graph.
2. Based on the graph of your splat test results, what can be said about the hypothesis that splat diameter is inversely proportional to viscosity? Did your results support this hypothesis? Why or why not?
3. Could you fit a straight line to your data? What does that mean?
4. What is the direction of the slope of your line? If you drop a new substance with a low viscosity, would you expect the splat diameter to be small or large?
5. Use your graph to determine the viscosity of glycerin. Find the splat diameter of glycerin along the y-axis of your graph. Trace a straight, horizontal line across your graph until it intersects your best-fit line. Go straight down your graph from this intersection and read the viscosity off the x-axis. What is your viscosity for glycerin? How does this compare to glycerin's true viscosity? What factors might account for the difference?
6. What is the class' range of values and mean value for the viscosity of glycerin?
7. What factors might account for the variability of results among lab groups? Identify three sources of error present in this experiment. How might you improve the experiment?