Science Learning Center
California State University, Long Beach
www.csulb.edu/slc

THE SOIL CRAFT STORE

Classroom Activity for Dig It! Soil Exhibition

Overview

This activity will teach students about the three different particles that make soil. Students will use models and ratios to determine soil composition and develop a better understanding of what soil is made of.

Audience

This activity is intended for students in grades 3-12 that visit the Science Learning Center. It could become part of an outreach activity or supplement an exhibit panel that features soil core samples or soil particle characteristics. Facilitation from volunteers or instructors will benefit all audiences.

Activity Length

30 minutes

Background

Activity Background

This activity will teach individuals about soil and what it is made of. They will have the opportunity to feel the different types of soil particles from samples that are provided. They will learn about ratios and percentages. Facilitators will guide students through their investigation, using open-ended questions and group discussions. Groups will be exploring the different types of soil composition from premade bottles. The bottles will be filled with a variety of different ingredients that represent the different soil particles. The bottles are a model for samples that geologists may collect in the field to develop a stronger understanding of soil composition.

Scientific Background

Soil is made up of three primary particles: sand, clay, and silt. Sand is the coarsest and biggest of the three grains, allowing for the most water drainage. This particle does not support many forms of agriculture because nutrients leach out easily. Silt has a fine texture that helps plants anchor their roots and develop microbial communities. Water drains slowly and this is an ideal soil for agriculture and urban development. Clay is the smallest grain and feels smooth or similar to flour. Air, water, microbes, and nutrients struggle with dispersal in clay soils and it is not ideal for growing crops. Clay-heavy soils act like a sponge and hang onto water; they are not as adversely affected during droughts because of this ability. Loamy soils (sand/clay) are best for construction. Not all soils all uniform and the ratios of each particle within the soil are critical for human activities and supporting biodiversity.

Testing soil ratios in a sample takes over 24 hours to allow finer particles to settle down to the bottom; craft materials make this task less intimidating, facilitate relatability, and accommodate for class time constraints. This activity mimics the soil samples that architects, civil engineers, historians, and soil scientists conduct in their own research. The ratios of the three primary soil particles can determine agricultural decisions, construction, or reveal information about a region's climate and hydrological activities. This information is compiled into the Soil Triangle, a diagram that identifies the type of soil based on their estimated ratios in a sample. Students will use the Soil Triangle and relate the ratios to common craft supplies in their simulated samples.

Learning Objectives

1. Students will know that soil is complex in its composition.
2. Students will use observations to identify materials based on their properties.
3. Students will understand what evidence is and use it to come to a conclusion.
4. Students will practice using estimates and ratios.
5. Students will learn how to use models as science investigation tools.

NGSS Science and Engineering Practices (SEPs)

- Planning and Carrying out Investigations
- Using Mathematics and Computational Thinking
- Engaging in Argument from Evidence
- Obtaining, Evaluation, and Communicating Information
- Developing and Using models

Common Core Standards (Math)

- Develop understanding of fractions as numbers (3-5)
    - CCSS.Math.Content.3.NF.A.1
    - CCSS.Math.Content.3.NF.A.2
    - CCSS.Math.Content.3.NF.A.3
- Understand ratio concepts and use ratio reasoning to solve problems (6-8)
    - CCSS.Math.Content.6.RP.A.1
    - CCSS.Math.Content.6.RP.A.2
- Modeling real-world scenarios (High School)

Materials and Cost

Materials

- Soil Triangle poster
- 3 plastic jars with a couple scoops of local soils
- Small containers to distribute real soil particles
- Simulated soil containers (4 combinations, 20 bottles total)
  - Pony beads
  - Spacer beads
  - Metallic hematite beads
  - Filled with tap water until full
- Laminated worksheets for students to report estimations of each bottle's contents
- Whiteboard markers and erasers for each station
- Answer key for instructor/facilitator
- Calculator on phone or computer

Shopping list

- Soil Triangle poster
  - Moveable knobs
  - Washers to attach knobs
- Small containers to pass out to tables
- Real soil
- Simulated soil containers
  - Large hematite beads
  - Small hematite beads to fill in gaps on bottom
  - Spacer beads
  - Pony beads
  - Simulated soil plastic containers
- Whiteboard markers
- Hand lenses
- Plastic jars

Cost

All items are considered non-consumable. Some items may need to be replaced as necessary due to damage or overuse. We expect that each classroom program will serve approximately 30 students.

The cost per learner is approximately $11.22.

Table 1 - Budget (one-time purchases)

Item	Price (individual item)	Total Cost	Cost per Learner
Soil Triangle poster:	-	-	-
-Knobs (3)	$1.60	$4.80	$0.16
-Washers (6)	$0.17	$4.25	$0.14
Soil particles	$15.00	$75.00	$2.50
Soil containers (10)	$36.00	$105.00	$3.50
Whiteboard markers	$9.00	$18.00	$0.60
Land lenses (10)	$16.00	$32.00	$1.07
Plastic jars (3)	$7.60	$7.60	$0.25
Simulated soil:	-	-	-
-Pony beads	$4.50	$13.50	$0.45
-Spacer beads	$10.00	$20.00	$0.67
-Large hematite	$7.83	$31.32	$1.04
-Small hematite	$9.80	$9.80	$0.33
-Containers	$1.06	$37.00	$1.23
TOTAL	-	**$358.27**	**$11.22**

Material Prep

1. Creating an interactive Soil Triangle poster
    a. Print poster onto thicker (i.e. foam core) surface
    b. Cut out grooves about 1 inch out from the triangle, along each side
    c. Draw and cut out large black lines that can extend from one side of the triangle to another (pipe cleaners may also be an option)
    d. Stick a washer on the end of the drawer knob screw, stick the screw through a poster groove, put another washer on top, and screw into the drawer knob.
    e. Attach the black lines to the moveable knob unit. This should create an interactive visual for how to use the Soil Triangle.
2. Print out enough six worksheets onto 8.5 x 11” cardstock and laminate. One side should be a worksheet, and the other side should have the Soil Triangle. (See Supplement 5)
3. Simulated soils
    a. Option #1: Divide the height of the fillable portion of the container (not including lid) by 10. Mark each 1/10 with a permanent marker on all containers.
    b. Option #2: Supply each group with a ruler that has metric and Imperial measurements.
    c. Fill containers with appropriate ratios of large/small hematite beads (sand), spacer beads (silt), and pony beads (clay).
        i. The containers should not be completely filled with beads. Allow at least 4/10 of the container to be filled with water.

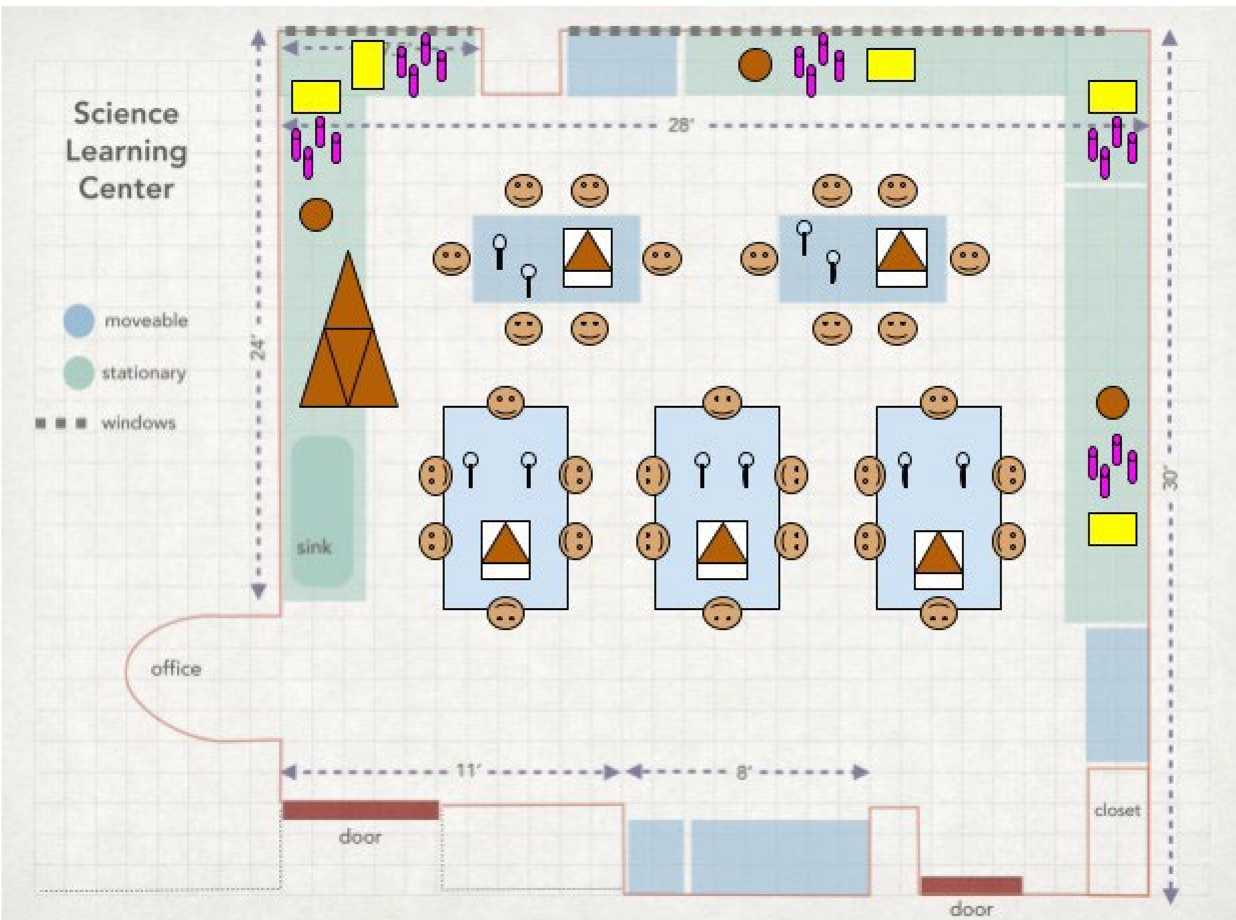
ii. Ratios on the Answer Keys should be adjusted accordingly.
iii. Label the bottle numbers on the lids with permanent markers.

4. Dump one 32 oz bag of a soil particle into one container. Labelling is optional.
5. Soil jar test (see Supplement 4)
    a. Fill each jar with two large scoops of local soil. This soil could come from campus, a backyard, a public park, or a local dirt pile.
    b. Fill the jar with tap water.
    c. Shake the jar vigorously for 2 minutes and allow it to rest overnight. The soils will take about 24 hours to fully settle with sand on the bottom, silt in the middle, and clay on the top layer.
        i. Mark off the sand layer after 1-2 minutes post-shaking.
        ii. Mark off the silt layer after 1-2 hours post-shaking.
6. Mark off the clay layer after 24 hours.

Activity Details

Set up

1. Set up the large Soil Triangle poster at the front of the room (big brown triangle).
2. Rearrange chairs/tables to create 5 groups of 6 students each.
3. At each group, distribute 1 laminated worksheet (white rectangle with brown triangle), 2 whiteboard markers, and 2-3 hand lenses (blue circle, black lines).
4. On the sides of the room, set out:
   a. 3 soil jar tests (brown circles).
   b. 1 silt, 1 sand, and 1 clay particle container, stacked (yellow rectangles).
5. Simulated soil combinations, 4 bottles each (pink cylinders).



Class Procedure

1. When the class enters the SLC, have them split into 5 groups of 6 students each.
2. Lead a group brainstorm to gauge prior knowledge (see facilitator guidelines)
3. Walk students through the interactive Soil Triangle poster--how to use it, who would use it, and the implications of identifying particle proportions in a sample.

4. Introduce the class to the three different soil particles and the soil jar test.
    a. Have students pick up soil boxes from the sides of the room and bring back to their group's table to begin their investigation.
    b. After they have time to explore soil textures, pass around the soil jar tests for students to see the ratios of each particle in context.
5. Have students retrieve the simulated soil bottles from around the room and begin estimating the ratios of sand, silt, clay particles in each bottle.
    a. Explicitly mention how the bottles are a model and the beads represent how each soil would settle.
    b. Challenge students to use the soil triangle on the back of the worksheet and name the soil classification of each bottle.
    c. Instructors should roam through the class and check in on students, probing for deeper understanding and monitoring their progress.
    d. Students can estimate ratios, count the number of particles in a container, or use another method to determine their simulated soil makeup.
        i. Calculations:
            1. Option #1: count the number of 1/10 that a layer takes up
            2. Option #2: measure the height of all soil layers as well as the heights of the individual layers
        ii. Students will relate the height of each soil particle layer and divide by the total height of the water sample
        iii. Multiply each number by 100 to convert ratio to a percentage
6. After 15 minutes, encourage groups to collaborate and share results with each other. Allow time for students to restrategize with their group if necessary.
7. Bring the group back together for a debrief of the different kinds of soil particles and what their experience was like during the investigation.
    a. Reveal the answers (ratios and soil names) and have them share their group's estimates.
8. Relate the experience back to real-world investigations when possible (i.e., why would a housing developer do a soil sample, what could it tell a historian).

Optional Challenges

- Practice unit conversions by having students who measure in inches to convert to centimeters, or vice versa.
- Provide students a ratio (44% clay, 37% silt, 19% sand) and have them identify the bottle that is closest to that ratio.
- Present real-world scenarios (An archeologist has found agricultural tools near the dig site and they want to know what the ancient civilization might have eaten. They likely ate legumes if the soil is a silty clay loam. Which bottle matches?)
- Encourage students to come up with a different method of estimating ratios or presenting their data (i.e., fractions to percentages)

**If there is not enough time to finish the activity, the facilitator should accommodate by allowing students to investigate and discuss 1 to 2 bottles instead of all 4. The facilitator can walk students through the worksheet as a class, as opposed to group exploration.

Clean-up

- Wipe off worksheets and allow for drying time before storing away.
- Disinfect whiteboard markers, hand lenses, and the outside of soil containers
- Reorganize the soil containers, simulated soil bottles, and other materials.
- Clean off the desks and stow away.

Activity Rationale

This activity was developed for the purpose of teaching visitors of SLC about soil and what it is made of. There are three main particles in soil, visitors will be exposed to the composition of soil and that not all soils are the same. There is a commonly used activity that served as our inspiration for this activity; it shows the different particles that exist in soil; however, this activity requires a 24-hour waiting period to let the soil settle and separate. Our solution to this problem is to provide visitors with models of the soil samples that are made out of common craft supplies. They can be reused which is financially beneficial to SLC and it also allows educators to control ratios of the models.

Throughout the development of the activity we found many teaching opportunities. We want visitors to experience what it is like to be a soil scientist and part of that is using the tools scientists use. We have included the soil triangle for this exact purpose. Since the triangle requires ratios to use it, this was a perfect opportunity to use what students are learning in school. They will be learning about decimals and fractions; these mathematical tools will help them estimate the amount of each particle that is in the soil to successfully use the soil triangle.

It is also a wonderful opportunity to expose younger visitors to the idea of ratios and separating the particles into groups.

Piloting the Activity

Due to the COVID-19 crisis, we were unable to pilot this activity or evaluate how effective various components are in practice. The following are things to consider when beginning to implement this classroom program *in situ*:

- How messy is the soil investigation? Is extensive clean-up required, or do students generally contain the mess above the containers?
- Estimating soil particles:
    - How accurate are students? Are they generally correct, or do ratios of each particle need to be adjusted?
    - Do students feel comfortable with presenting data on ratios, fractions, and percentages? Are some age groups less comfortable than others?
    - Do the particles consistently settle the way they should, even with repeated use or with different concentrations than the model?
- Can students effectively use their Soil Triangles or do they express discomfort with that particular tool? How does the facilitator's use of the interactive Soil Triangle change student confidence or answers?
- What messages are students taking away from participation in this activity? Do they match the learning objectives of this activity or the *Dig It!* exhibition overall?

Activity Resources

The following resources are available at the end of this document.

- Supplement 1: Facilitator Guide
- Supplement 2: Answer Key
- Supplement 3: Soil Triangle Poster
- Supplement 4: Glass Jar Soil Test
- Supplement 5: Worksheet

Supplement 1:

Facilitator Guide

[Any words written in blue with square brackets are for facilitators' physical actions and guidance.]

Objective

This activity will teach students about the three different particles that make up soil.

Curriculum

Grades 3-12

Program Outline

Students will have the opportunity to feel the different types of soil particles and learn about ratios and percentages. Groups will be exploring the different types of soil composition from prepared simulated soil bottles. The bottles represent samples that geologists or others may collect in the field to develop a stronger understanding of soil composition.

Materials

- Simulated soil bottles
  - Pony beads
  - Spacer beads
  - Hematite beads
  - Filled with tap water until full
- Easel (?)
- Interactive Soil Triangle poster
- Soil jar tests (3)
- Worksheets
- Dry erase markers

DISCLAIMER These materials may have to be modified after testing.

Supply availability and testing are currently impacted due to store closures and supply chain shortages during the COVID-19 pandemic.

Setup

1. Set up the large Soil Triangle poster at the front of the room (big brown triangle).
2. Rearrange chairs/tables to create 5 groups of 6 students each.
3. At each group, distribute 1 laminated worksheet (white rectangle with brown triangle), 2 whiteboard markers, and 2-3 hand lenses (blue circle, black lines).
4. On the sides of the room, set out:
   a. 3 soil jar tests (brown circles).
   b. 1 silt, 1 sand, and 1 clay particle container, stacked (yellow rectangles).
   c. Simulated soil combinations, 4 bottles each (pink cylinders).

[When the class enters the SLC, have them split into 5 groups of 6 students each.]

Presentation

Can anyone tell me what soil is made of?
Soil is a combination made of three different particles: silt, sand, clay.

Does anyone know what we call a person that studies soil?

- Soil scientist/geologists
- Other people may study soil too, like construction workers who make buildings or archeologists who want to learn more about how ancient peoples lived.
- Usually geologists collect real soil samples from different places but today our bottles will represent our soil samples. This is what we also call a model - a model is something you use as an example, instead of the real object.

Why do you think they collect soil?
It can be analyzed in a laboratory to look at the pH, salinity, nutrient content, and microbes. They also collect soil to look at composition and texture.

Geologists use a special tool to help them with this: a Soil Triangle.

- **How do you think this is used by scientists?**
  We are going to try and figure out how much of each particle is in each of our soil samples.

- **Look carefully at the parts of the triangle. How do you think we use this tool?**
  Let's learn together. [You can use your real soil sample bottle to help you with this portion.]

- **Do you notice what's on the three sides?**
  Yes. Our three particles! Silt, Sand and Clay.

- **What do you think these small knobs are for?**
  Once we think we know how much silt is in our soil sample, we can move the lines up and down until it reaches that number. [Do the same with the other clay and sand – maybe ask a student to demonstrate.] All three will point to one spot on the triangle and it'll tell us what kind of soil we have.

Activity

[Have a student from each group pick up soil boxes from the sides of the room and bring back to their group's table to begin their investigation. Allow students to touch, feel, and see the different textures of each particle.]

Today we are going to feel different particles, individually.

[While they are becoming familiar with the textures ask them what physical properties they notice about the different particles. Note: you may have to remind students that soil is usually a combination of all three and you don't usually see them alone like this.]

- ***Do you see a difference between the three?***

- ***Oh look, that clumped together, do you know why?***

- ***What do you notice about the particles?***

We also have these bottles that are our soil sample models.

These three particles are very similar to the particles in our bottles. If you look in the bottles; you'll notice there are three different types of particles. [Explain how the items in the bottle represent the soil particles.]

- Spacer beads = Silt
- Hematite beads = Sand
- Pony beads = Clay

[Hand out a set of 4 mystery bottles to each student group OR allow one student from each group to pick up the different tools they need. *Note: this is a great time to ask for volunteers to help you pass out bottles and worksheets.]

Your challenge is to figure out what type of soil you have in each bottle. Look at how much of each ingredient is in your bottle and see if you can use the soil triangle and your worksheet to help you determine what kind of soil you have. You can show how much soil you have any way you want to--decimals, fractions, percentages, whatever you think will help you figure out this challenge. [Walk around the room and offer help whenever needed. This is a time for students to work with each other and naturally problem solve.]

- ***Grades 3-4:*** [help them by asking how to separate] ***Is there more than half or less than half?***

- ***Grades 5-12:*** [Students begin decimals and percentages at 5th grade and should be practicing these mathematical skills, providing assistance when needed. If groups are moving through the activity quickly, feel free to provide *additional challenges* for them to solve together as a class or in small groups.]

Optional Challenges

- Provide students a ratio (44% clay, 37% silt, 19% sand) and have them identify the bottle that is closest to that ratio.
- Present real-world scenarios ("An archeologist has found agricultural tools near the dig site and they want to know what the ancient civilization might have eaten. They likely ate legumes if the soil is a silty clay loam. Which bottle matches?")
- Encourage students to come up with a different method of estimating ratios or presenting their data (i.e. fractions to percentages)
- Students can head outside to grab a sample of soil from around the Science Learning Center and begin a new Soil Jar Test for future SLC guests or students!

[After 15 minutes, encourage groups to collaborate and share results with each other.]

- ***What did your group do to estimate the ratios?***

- ***How similar or dissimilar are your answers?***

- ***Do you want to try a different method to find the answers?***

[Have students break apart into their original groups for a few more minutes, revising their answers if necessary.]

[Bring the group back together for a review of the different kinds of soil particles and their inquiry experience. Reveal the answers and debrief with them about their group's estimates. Relate back to real-world investigations when possible.]

- ***How did you know which bottle was which recipe?***

- ***What are the different sizes of particles?***

- ***Are all soils the same? Why or why not?***

- ***How do different soil types relate to construction? Agriculture? Droughts?***

- ***What would you do to come to these same conclusions in the field?***

Clean-up

- Wipe off worksheets and allow for drying time before storing away.
- Disinfect whiteboard markers, hand lenses, and the outside of soil containers.
- Reorganize the soil containers, simulated soil bottles, and other materials.
- Clean off the desks and stow away.

Supplement 2:

Answer Key

Bottle 1 (Clay)

- 50% Pony beads
- 20% Spacer beads
- 30% Metal beads

Bottle 2 (Loam)

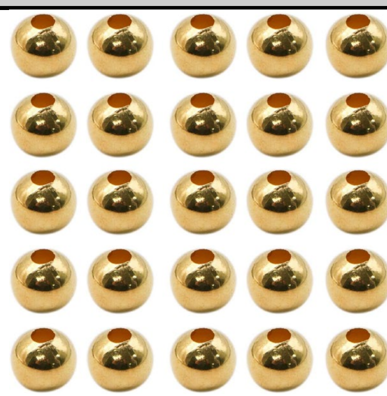
- 22% Pony beads
- 37% Spacer beads
- 41% Metal beads

Bottle 3 (Clay Loam)

- 33% Pony beads
- 33% Spacer beads
- 33% Metal beads

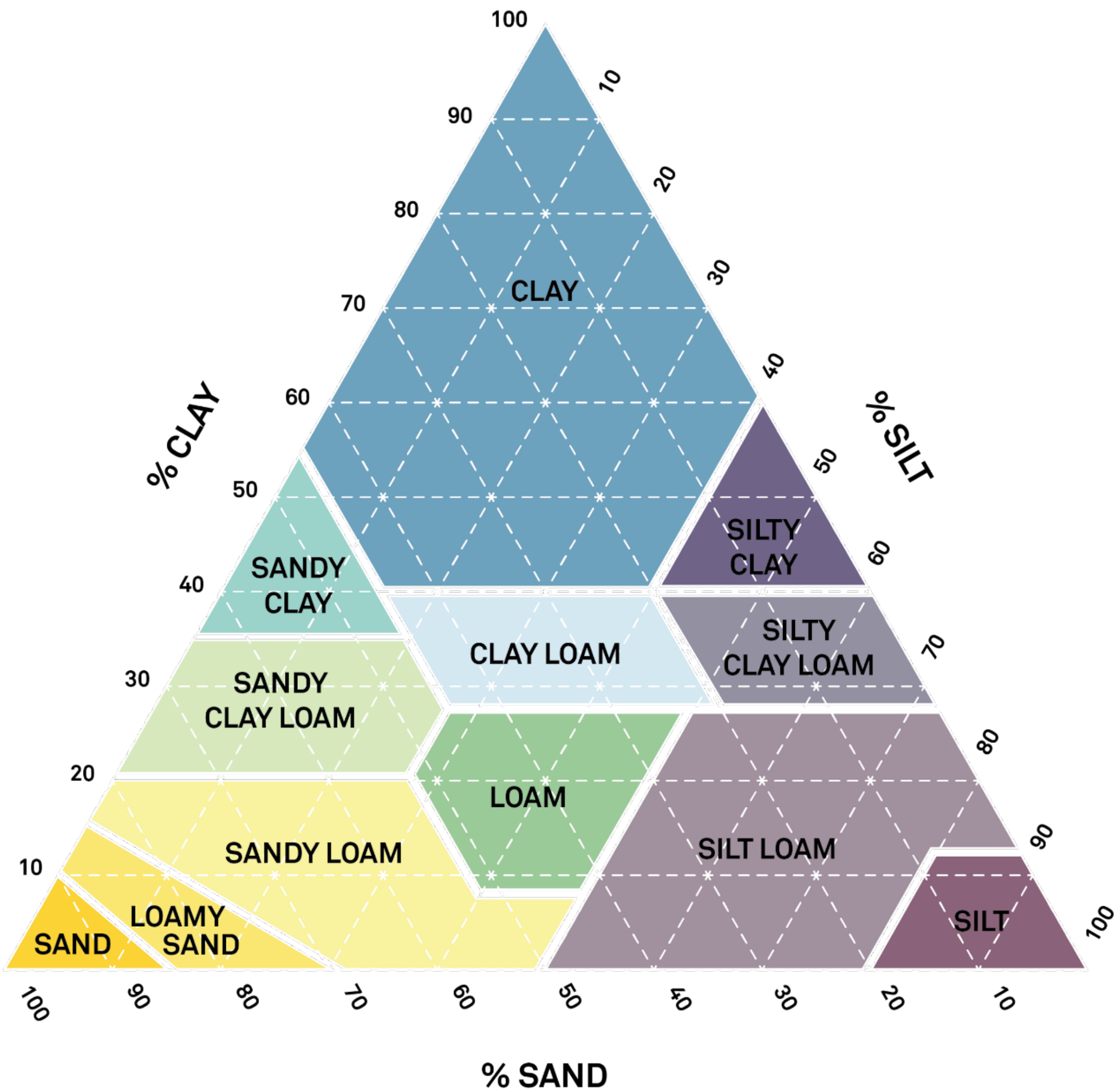
Bottle 4 (Silt Loam)

- 10% Pony beads
- 60% Spacer beads
- 30% Metal beads

Pony beads	Spacer beads	Hematite beads
“Clay”	“Silt”	“Sand”
		

Supplement 3:

Soil Triangle Poster

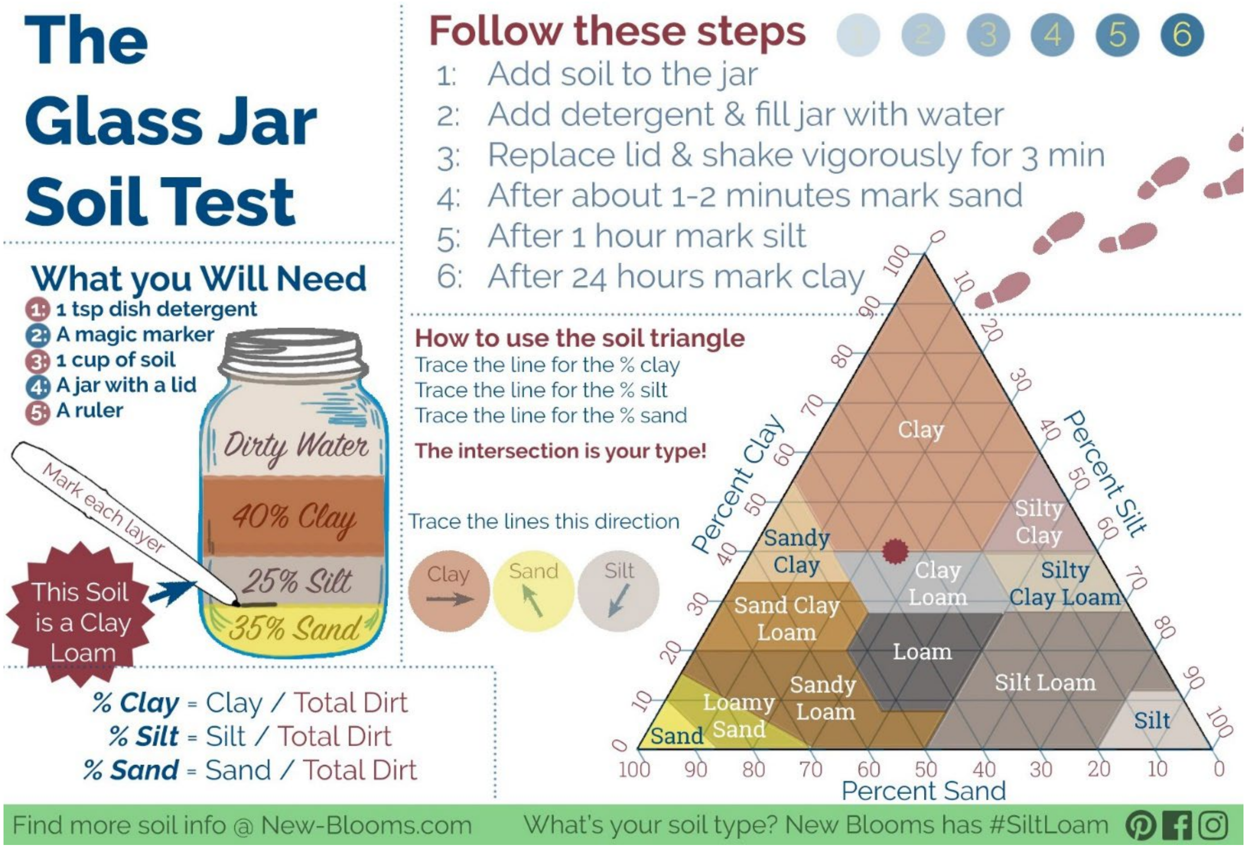


Printed out as a large poster, becomes interactive with moveable knobs/lines on the back of student worksheets to assist with investigation.

Source: https://www.metergroup.com/environment/articles/which-soil-sensor-is-perfect-for-you/

Supplement 4:

Glass Jar Soil Test



Source: NewBlooms.com

Supplement 5:

Worksheet (Side 1)

Sand

Clay

Silt

Clay: ____________________

Silt: ____________________

Sand: ____________________

Supplement 5:

Worksheet (Side 2)